The Federal Plan for Meteorological Services And Supporting Research

FISCAL YEAR 1981

FEDERAL COORDINATOR FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

FCM 80-3

U.S. DEPARTMENT OF COMMERCE/National Oceanic and Atmospheric Administration

FEDERAL COMMITTEE FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

MR. T.B. KINNEY, JR.
Department of Agriculture

DR. GEORGE S. BENTON, Chairman
Department of Commerce

DR. T.B. OWEN, Federal Coordinator
Department of Commerce

MR. ALONZO SMITH, Secretary
Department of Commerce

Dr. ARDEN BEMENT
Department of Defense

MR. DAVID SLADE
Department of Energy

MR. ALBERT TRAKOWSKI
Environmental Protection Agency

MR. ROBERT C. CRAWFORD
Federal Emergency Management Agency

MR. HARRY AVERY
Department of Interior

DR. LAWRENCE R. GREENWOOD
National Aeronautics & Space Administration

DR. FRANCIS S. JOHNSON
National Science Foundatin

MR. JOHN DYER
Office of Management and Budget

DR. JOHN DARDIS
Department of State

MR. WARREN C.SHARP
Department of Transportation

THE INTERDEPARTMENTAL COMMITTEE FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

MR. T.B. KINNEY, JR.
Department of Agriculture

MR. WILLIAM S. BARNEY, Chairman
Department of Commerce. NOAA

DR. RICHARD E. HALLGREN
Department of Commerce
National Weather Service

MR. ALONZO SMITH, JR.,
Executive Secretary
Department of Commerce, NOAA

COL. ELBERT W. FRIDAY, USAF
Department of Defense

DR. HARRY MOSES
Department of Energy

MR. L.E. NIEMEYER
Environmental Protection Agency

MR. ROBERT C. CRAWFORD
Federal Emergency Management Agency

MR. HARRY AVERY
Department of Interior

DR. SHELBY TILFORD
National Aeronautics and Space Administration

DR. EUGENE BIERLY
National Science Foundation

MR. JOHN DYER
Office of Management & Budget

MR. MYRON P. LEWIS, JR.
Department of Transportation/
Federal Aviation Administration

CDR ROBERT E.HAMMOND, USCG
Department of Transportation/
U.S. Coast Guard

U.S. DEPARTMENT OF COMMERCE
Philip M. Klutznick, Secretary

National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator

The Federal Plan for Meteorological Services And Supporting Research

FISCAL YEAR 1981

MARCH 1980
WASHINGTON, D.C.

PREFACE

This Federal Plan is the sixteenth in an annual series, produced in compliance with Section 304 of Public Law 87-843, to provide the Congress with a description of governmental programs in meteorology, and to outline the specific functions and funding requested by each Agency involved. The Plan is assembled by the Department of Commerce, in accordance with Circular A-62 (published by the then-Bureau of The Budget on November 13, 1963), which provided for a systematic and continuing review of basic and specialized meteorological services and supporting research.

To perform this function, the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) was established by the Department of Commerce. Until CY1979, the principal effort in coordinating government activities in the services and supporting research field was performed by two committees - The Interdepartmental Committee for Meteorological Services (ICMS), and the Interdepartmental Committee for Applied Meteorological Research (ICAMR).

During CY1979, these committees were merged into a single Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) to optimize the review process. In addition to the generalized function of performing coordination of Federal meteorological activity, and providing inputs for the annual Federal Plan, the ICMSSR is also charged with preparing special Plans covering specific areas of common interest.

Activities of the Joint Committee for Space Environmental Forecasting, and the Interagency Committee for the World Weather Program are documented elsewhere, and are not included in this Plan.

T. B. Owen
Federal Coordinator for
Meteorological Services and
Supporting Research

THE FEDERAL PLAN FOR METEOROLOGICAL SERVICES
AND SUPPORTING RESEARCH

FY 1981

TABLE OF CONTENTS

TABLES

SECTION I

WEATHER ACTIVITIES IN THE FEDERAL GOVERNMENT

AGENCY ROLES AND ACTIVITIES.

Weather plays an important role in the United States, and eight agencies of the Federal Government engage in or make significant use of weather services and supporting research. These agencies collectively have the following broad program goals for their weather activities:

- Promote the economic and social well-being of the nation.
- Enhance the national security.
- Minimize the financial and social disruptions caused by weather-induced disasters.
- Preserve and enhance the environment.

A generalized statement of activities of each of the principal Federal agencies so engaged is presented below:

Department of Agriculture (USDA).

The Nation's food and forest resources are becoming increasingly important to our domestic and international economic situation, and food has recently taken on new dimensions in foreign affairs and national security. Weather, and its effect on crop yields, is one of the most important factors in the Nation's agricultural production. The USDA conducts supporting research that focuses on understanding the interactions between weather and climate with plants and animals. USDA also aids the Department of Commerce in determining farmers' needs for weather information and in disseminating such information to them.

Department of Commerce (DOC).

DOC's National Oceanic and Atmospheric Administration (NOAA) is the principal meteorological agency of the Federal Government. By law, NOAA is responsible for reporting the weather of the United States and providing weather forecasts and warnings to the general public, developing and furnishing specialized weather services for specific user groups, and recording the climate of the United States. This mission is carried out within NOAA by the National Weather Service (NWS), National Environmental Satellite Service (NESS), Environmental Research Laboratories (ERL), and the Environmental Data and Information Service (EDIS).

NWS carries out data acquisition, forecasts and warnings preparation, communications, product dissemination and applied research and development functions. Public weather services focus on information needed by the general public in its daily activities. Warnings are aimed at reducing loss of life and property caused by weather events. Special meteorological services provide information to enhance the efficiency and safety of agricultural, forestry and transportation industries.

NESS provides pictures and quantitative data of the earth and its environment to meet all civil and many military needs. NESS operates a national environmental satellite system of polar-orbiting and geostationary satellites. Research and development activities within NESS are directed toward improved observing sensors and techniques and new applications for environmental satellite data. NESS specifies the performance of the spacecraft and NASA acts as their contractor to build, procure and launch them.

ERL research programs are oriented toward providing the understanding of the atmosphere and oceans and developing the new technologies that will form the basis for future improvements in the Nation's weather services.

EDIS disseminates global meteorological and climatological information to commerce, industry, agriculture, the scientific and engineering community, the general public, and Federal, state and local governments.

Department of Defense (DOD).

DOD operates a military environmental service system to provide tailored worldwide meteorological and oceanographic prediction services in support of military forces. This service directly supports all phases of military operations, from strategic planning to tactical operations. The U.S. Navy's Naval Oceanography Command and the U. S. Air Force's Air Weather Service are the primary military performing agencies. The Army and the Marine Corps each have a small generic weather support capability; however, they depend upon the primary weather services for most support. The military weather services contribute to the national and international weather observing capability by making conventional observations on land and at sea where there is no other conventional weather observing capability and where the observations are most needed to meet military requirements. In addition, DOD maintains special observing capabilities such as the Defense Meteorological Satellite Program and aerial weather reconnaissance to meet unique military requirements. The reconnaissance program also serves national needs for data from tropical and coastal winter storms. Observational data are sent by military communications networks to military and civil facilities in the United States and overseas.

Department of Energy (DOE).

The DOE supports meteorological services at nine of the National Laboratories under DOE cognizance, and the Nevada Test Site. Services include climatological summaries in general, daily weather forecasts and items specifically in support of laboratory operations such as environmental monitoring, atmospheric sciences research, and hazardous material release assessments. The Weather Service Nuclear Support Office at the Nuclear Test Site provides continuing meteorological services required for the safety and technical programs associated with nuclear and non-nuclear experiments conducted by the DOE at the test site and other locations.

Department of Transportation (DOT).

Federal Aviation Administration:

The Federal Aviation Administration (FAA) is responsible for the safety and separation of aircraft and the efficiency of flight operations. The adequacy of aviation weather information contributes significantly toward the fulfilling of these responsibilities. FAA makes recommendations to the U.S. Department of Commerce on civil aviation meteorological services, provides specialized equipment and surface observations at certain airfields, distributes weather data over civil communications systems and represents the principal means for disseminating weather information to pilots.

Weather information for pilots is made available through flight service stations, recorded messages, broadcasts over navigational aids, special weather broadcasts and telephone answering systems. Thirteen Air Route Traffic Control Centers now have weather service units manned by NWS meteorologists to assure that vital weather information is available to controllers.

FAA maintains a continuing research program to improve aviation weather service to the National Airspace System and its users. FAA also engages in engineering efforts to improve weather observations and communications related to aviation.

U.S. Coast Guard:

The U. S. Coast Guard cooperates with the NWS in observing, forwarding, and disseminating weather information. Observations taken by Coast Guard units and those from coastal and high seas commercial shipping are sent to NWS offices. Some NWS automated observing systems are located at Coast Guard stations and on navigational buoys. NWS forecasts and warnings for coastal and high seas are included in the scheduled Coast Guard Marine Information Broadcasts.

Coast Guard personnel stationed at the NOAA Data Buoy Office at Bay St. Louis, Mississippi, furnish technical support and liaison for NOAA Data Buoy operations. Coast Guard vessels are employed to deploy and maintain NOAA data buoys.

Environmental Protection Agency (EPA).

The Environmental Protection Agency is responsible for working with State and local government agencies to ensure adequate meteorological support for air quality programs. Applied research and meteorological support to EPA is provided by NOAA's Air Resources Laboratories. Support to the Office of Air and Waste Management, the EPA regional offices and other EPA components includes review of the meteorological aspects of environmental impact statements, state implementation plans, application of dispersion models and preparation of dispersion studies and evaluation.

National Aeronautics and Space Administration (NASA).

The NASA weather and climate program is an integrated effort to develop new tchnology for use in improving the quality of meteorological information to meet national needs. A central assumption to all of NASA's efforts is that by use of satellite remote sensing systems, much of the needed data can be collected and processed in a more cost-effective manner than by any other means. The NASA program may be divided into three components:

- o Developing coordinated space and ground systems for severe storm detection, prediction and warning.
- o Applying space technology to improve forecasting for periods up to two to three weeks.
- o Investigating the potential for monitoring and predicting climate changes.

National Science Foundation (NSF).

The National Science Foundation supports meteorological research primarily at universities and non-profit institutions under its Atmospheric Sciences Division. Although most of this research is fundamental with no immediate application to meteorological services, a limited portion of that research may lead to early improvement in these services.

COSTS OF WEATHER SERVICES.

The Federal agencies spent $776 million in FY1979 and plan to spend $831 million in FY1980 and $915 million in FY1981 for weather services and supporting research. It is useful to look at these expenditures in terms of each agency's spending for various types

of services and in terms of the functions those agencies perform or support.

Table 1 shows agency costs for operations and supporting research for FY1980 and FY1981. Table 4 shows how these costs are divided among the various services.

WEATHER PROGRAM TRENDS.

Over the past decade, Federal costs for weather activities have increased approximately 80% or $416 million from FY1971 to FY1981. This is almost exactly the same as the increase in cost of government purchases of goods and services calculated by the Bureau of Economic Analysis for that period. These comparisons do not present the entire situation; the nation's weather services have done more than merely keep pace with inflation. There have been introductions of new technology to improve both services and staff productivity.

New Technology for Improving Services.

The principal new technologies that have been introduced by the weather service agencies in the past decade are:

- Geostationary Satellites -- These spacecraft maintain near-continuous imaging of the weather over the western hemisphere for both civil and military uses. The system has added nearly $40 million annually to the DOC/NOAA budget.

- NOAA Weather Radio -- A national network of approximately 350 VHF/FM stations provide 24-hour broadcasts of weather warnings and information. The system has added more than $5 million annually to the budget.

- New computers at Major Weather Centers -- Over the past decade, DOC and DOD have replaced the large computer systems at their major numerical weather processing centers. The new computers have improved public weather forecasts and warnings and permitted DOD to move into many new military support activities. In addition DOC replaced its very large R&D computer system used to study and model the earth's atmosphere and oceans.

- Data Buoys -- DOC has developed and deployed a network of data buoys off the U.S. coastline to provide information on weather and sea conditions vital to storm warnings and understanding of the marine environment in our offshore energy areas. This program has an annual cost in excess of $8 million.

New Technology for Staff Productivity

The principal new technologies for improving employee productivity are:

- Automation of Field Operations and Services (AFOS) -- This DOC program was initiated in 1975 to replace some of the labor-intensive functions in the National Weather Service field offices with modern alphanumeric and graphic technology. AFOS, now coming on line, represents capital costs in excess of $45 million.

- Automatic weather observing stations have been developed and are now ready to go into operation to improve staff productivity as well as provide better service to the nation.

Employment.

Overall, there has been a general downward trend in the number of Federal employees engaged in weather activities. This has been achieved by use of contracts for services that do not have to be performed by Federal employees, by introduction of labor-saving technology and by terminating lower priority activities. A number of small marginally productive facilities remain in operation serving the general public and specialized user groups.

Federal employees, civil and military, have been reduced from about 25,500 in 1970 to 18,578 in 1980, a decrease of about 6,900 or 27%. The largest decrease was in the Department of Defense, reflecting the post-Viet Nam phase-down of military operations. The U.S. Coast Guard personnel engaged in weather activities decreased by 1,300 as the ocean station vessel program terminated and their Lighthouse Automation Program was implemented. Department of Commerce operational weather personnel decreased by 730, reflecting productivity improvement and termination of many reimbursable projects performed for other agencies. The Department implemented several major new programs during this decade that required significant staff resources. Local warning radars and NOAA weather radio are examples of such programs.

OUTLOOK.

Demands for more and better weather forecasts and warnings have grown much the same as other demands for services from the Federal government, reflecting the increasing sensitivity to weather events such as storms, temperature extremes and droughts. New technology such as weather satellites and computers have improved services and employee productivity but have added to costs. It is useful to examine what some of the non-inflation forcing factors on costs will be in the future.

Technology.

The general field of remote sensing technology has made significant strides in the past five years and unquestionably will

have a major impact on both future directions and costs of weather activities. For example, R&D has established that major improvements in tornado and severe thunderstorm warnings can be achieved by using a new radar technology. The agencies are preparing a $250-300 million program over the next decade to replace aging radars with new ones using the new technology. A research and development program is under way to examine other remote sensing technology and to design an integrated observing and forecasting system for major urban areas. While services will improve, capital costs will be substantial.

New technology is also at hand to automate several labor-intensive functions. Several agencies have proposed a $250-500 million program over the next decade to automate surface weather observations at civil and military weather stations nationwide. While expensive in terms of capital investment, the program has the potential for reducing staffs and shifting others to more productive work. It appears that computer-based technology (for example, voice inputs for aviation and adaptations for agriculture) will become operational in the next few years with potential for major productivity improvements in those agencies involved in dissemination of information to the public, pilots and users, such as farmers. A great deal more information will be available to users at a lower staff cost by use of "talking computers".

The technology of computerized weather forecasting can be expected to move ahead on an evolutionary basis. New models will be developed, creating new demands for larger, faster computers. DOC and DOD are in the process of replacing and upgrading their large weather computers. The new equipment can reasonably be expected to meet needs for the better part of the 1980's.

CONGRESSIONAL CONCERN.

Several teams from the General Accounting Office (GAO) have been looking at various aspects of Federal weather activities. The most comprehensive of these led to a GAO Report to the Congress in October 1979 entitled, "The Federal Weather Program Must Have Stronger Central Direction." The thrust of the report is that there are some cases of apparently unwarranted duplication and the planning and coordinating mechanism had become ineffective and unable to cope with the problems. The actions by the Departments of Commerce, Defense and Transportation to revitalize the planning and coordination function is an effective step that will be responsive to the problems cited by the GAO. (See further discussion under Section 3.)

The Congress has consistently supported weather programs such as radars, satellites and computers, which are most important contributors of information to the natural disaster warning systems.

Section 2

RESOURCE INFORMATION AND ANALYSIS

Resource information contained in this plan is based on the President's FY1981 Budget. Appropriated amounts may vary depending upon Congressional action on the individual agency budgets.

AGENCY OBLIGATIONS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH.

Table 1 summarizes funding for meteorological operations and supporting research for FY1980 and the requested amounts for FY1981. This table shows that agencies plan to spend a total of $836,158 thousand in FY1980 and have requested $907,134 thousand for FY1981. This represents a net increase of $70,976 thousand or 8.5%. This change, as in past years, is composed of program increases, program decreases, and changes in the cost of continuing on-going activities due primarily to pay raises and inflation. The most significant program changes from FY1980 to FY1981 are discussed in the following paragraphs.

Department of Agriculture (USDA).

There are no increases in USDA meteorological operations or supporting research. The funding amounts shown have been increased slightly to reflect changes in categorization of some activities in the U.S. Forest Service and in the Science and Education Administration.

Department of Commerce (DOC).

The principal program changes from FY1980 to FY1981 planned by the National Oceanic and Atmospheric Administration are:

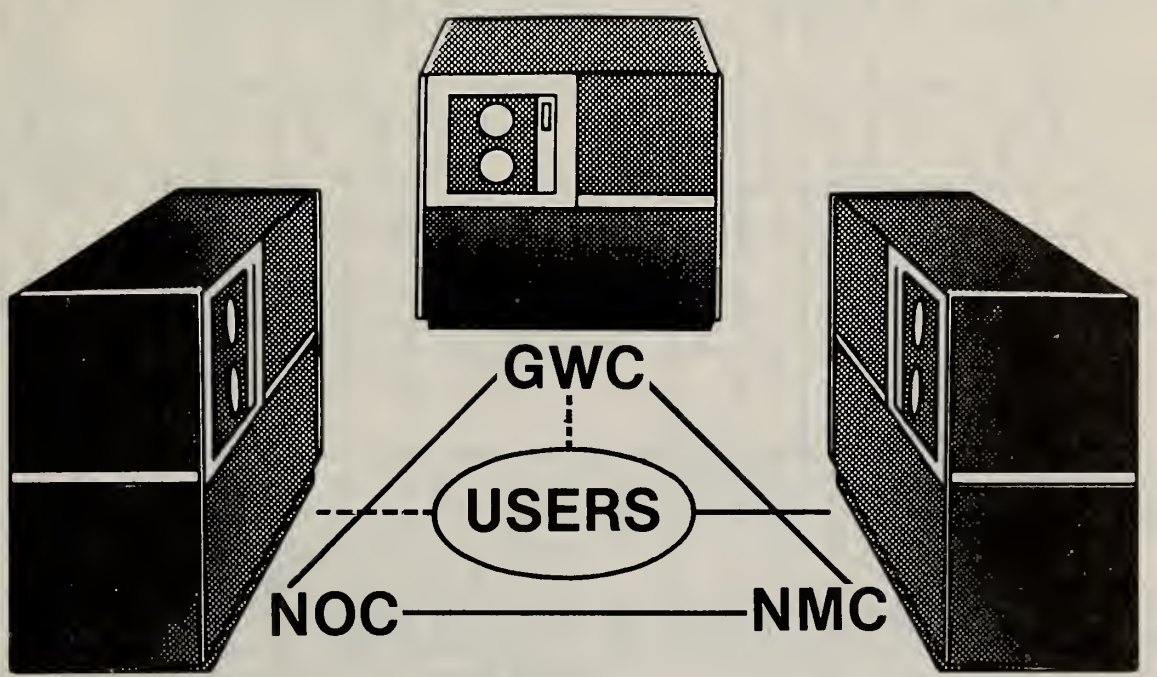
- The National Weather Service plans to initiate two long-term programs to automate surface observations at field offices, at coastal sites, and on offshore platforms. This program increase of $3,400 thousand is NOAA's portion of a coordinated effort by the Departments of Defense, Transportation and Commerce to bring new technology to bear on observational problems and as a means of improving staff productivity.

- A joint program involving DOC/NOAA, DOD and DOT/FAA to initiate final development and procurement of a new weather radar system is proposed for FY1981. This radar, termed NEXRAD, employs the Doppler principle and has demonstrated over the past three years that it can make very significant improvements in warnings for severe thunderstorms and

tornadoes and enhance aircraft safety. NOAA's request of $2,000 thousand is its part of the $4,300 thousand the three ageencies are requesting for this new program.

- A coordinated new and improved marine weather service, focused on the coastal and offshore areas in cooperation with the U.S. Navy is proposed. The $500 thousand increase will provide for establishing and operating three ocean service units as elements of existing weather service forecast offices.

Three large numerical processing centers provide basic and specialized products to civil and military users. Mutual backup arrangements assure that vital service products are not lost when computers fail.



U. S. NAVAL NUMERICAL OCEANOGRAPHY CENTER (NOC),
U. S. AIR FORCE GLOBAL WEATHER CENTER (GWC), AND
NATIONAL METEOROLOGICAL CENTER (NMC) OF THE NATIONAL WEATHER SERVICE

AGENCY	OPERATIONS			SUPPORTING RESEARCH			TOTAL		
	FY80	FY81	Net Difference	FY80	FY81	Net Difference	FY80	FY81	Net Difference
Agriculture	750	776	+ 26	6770	6770	0	7520	7546	+ 26
Commerce	312061	330028	+17967	23840	27604	+3764	335901	357632	+21731
Defense	249069	276708	+32639	56305	56346	+ 41	305374	333054	+27680
Energy	3136	3485	+ 349				3136	3485	+ 349
Transportation-Coast Guard	1240	1351	+ 111				1240	1351	+ 111
Transportation/FAA	104940	116641	+11701	12447	13225	+ 778	117387	129866	+12479
EPA	500	500	0	8000	8000	0	8500	8500	0
NASA	790	784	- 6	50410	72316	+21906	51200	73100	+21900
NSF				700	700	0	700	700	0
TOTAL	762486	730273	+62787	158472	184961	+26489	830958	915234	+84276

TABLE 1
METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH BY AGENCY
(Thousands of Dollars)

- Implement a National Oceanic Satellite System (NOSS) to sense oceanic phenomena.

- NOAA is proposing to expand its Weather Wire Service, a teletypewriter system that delivers weather information and warnings to the media and state and local governments, in all of the 48 contiguous states. The requested increase will provide for lease of equipment and communications circuits on a continuing basis.

- An increase of $400 thousand is proposed for the NOAA National Climate Program Office, responsible for the broad scale planning required by the National Climate Program Act, PL 95-367. (See discussion in Section 4.)

- NOAA is proposing several increases and decreases in its environmental satellite program in FY1981. These are:

  (1) Continuing procurement of polar-orbiting spacecraft requires an increase of $6,809 thousand.

  (2) Reimbursing the U.S. Air Force for Atlas launch vehicles requires an increase of $8,525 thousand.

  (3) Procurement of geostationary spacecraft will require $2,409 thousand more in FY1981 than in FY1980.

  (4) NOAA to NASA for launching geostationary spacecraft will decrease $16,088 thousand from FY1980.

  (5) Eliminating integration and testing of the Solar Backscatter Ultraviolet (SBUV) instrument for flight on the NOAA-G spacecraft permits a reduction of $1,800 thousand in FY1981.

- NOAA plans to reduce the level of effort devoted to development of its Shipboard Data Acquisition Systems (SEAS) by $260 thousand in FY1981, to allow higher priority programs to proceed.

- Modification of earlier plans to upgrade the NOAA computers at Suitland, MD permit a reduction of $350 thousand from the originally planned amount.

- The National Weather Service Pacific Region Headquarters in Honolulu, HI will be reduced and funding needs curtailed by $318 thousand.

Department of Defense (DOD).

The program changes from FY1980 to FY1981 in the Department of Defense are presented for the U.S. Air Force and the U.S. Navy; no significant program changes are planned for the U.S. Army.

- o U.S. Air Force.

  (1) The most significant increase in FY1981 ($22,975 thousand) is for procurement of Defense Meteorological Satellite Program spacecraft and sensors and for launch vehicle costs. Satellite acquisition is acyclic: those now in orbit were funded in the mid-1970s. This current acquisition is for mid-1980's delivery.

  (2) At the Air Force Global Weather Central, an increase of $6,020 thousand is associated with maintenance of the new Satellite Data Handling System and for development of an Interactive Processing and Display System.

  (3) Other significant changes include an increase of $1,393 thousand for emergency maintenance modifications of the FPS-77 storm detection radars, to extend their useful life through the late 1980s: a decrease of $2,973 thousand due to a reduction in requirements for rocketsonde measurements; and an increase of $2,080 thousand for additional training of all types of meteorological personnel. This returns the training program to a stable level.

- o U.S. NAVY.

  (1) The U.S. Navy is planning to procure earth terminals to receive images and information from Defense Meteorological Satellite Program spacecraft and meteorological observing sensors at a cost of $1,512 thousand in FY1981.

  (2) Significant decreases from FY1980 to FY1981 are also planned for equipment procurement. Expenditures for Naval Environmental Display Systems will decrease $1,782 thousand and procurement of Defense Meteorological Satellite Program equipment for aircraft carriers will decrease by $1,444 thousand. In addition, Navy expenditures for satellite antennas and automatic weather station test equipment will decrease $550 thousand.

Department of Energy (DOE).

No significant changes were reported.

Department of Transportation (DOT).

Program changes from FY1980 to FY1981 within DOT are presented for the Federal Aviation Administration and the U.S. Coast Guard (USCG).

- Federal Aviation Administration.

  (1) The Federal Aviation Administration is requesting an additional $9,931 thousand for its surface weather observation program activities in FY1981. This includes funding for new sensors such as cloud base height indicators as well as for automated observing equipment.

  (2) A decrease of $772 thousand is planned in closed circuit TV display systems and an additional decrease of $925 thousand in FY1981 results from a recomputation of workload costs for transcribed weather broadcasts.

- U.S. Coast Guard.

  (1) Changes in two USCG programs will reduce costs in FY1981 by $78 thousand. The USCG program to automate its light stations will permit withdrawal of personnel from eight more locations, thereby reducing weather-related costs. In addition, conversion of NOAA data buoys from HF radio to satellite data links allows the USCG to reduce its support costs.

Environmental Protection Agency (EPA).

No major changes were reported.

National Aeronautics and Space Administration (NASA).

The principal program changes planned by NASA in FY 1981 are:

- An increase of $1,500 thousand is being requested for studies of data collected under the World Meteorological Organization's Global Atmospheric Research Program. These studies are for the purpose of defining advanced remote sensing instruments and for new atmospheric models. In addition, $1,000 thousand is planned for advanced satellite instrumentation definition.

- NASA plans to spend $4,000 thousand developing an ozone sensor as part of its operational satellite improvement program. This new sensor is intended to provide NOAA spacecraft with the capability to monitor atmospheric ozone levels as directed by the Congress.

- Climate program activities in NASA require an additional $1,700 thousand for data sets, climate observations and special studies and analyses.

National Science Foundation (NSF).

As of FY1981, the Atmospheric Sciences Division of the National Science Foundation has begun reporting basic research activities which would ultimately improve either basic or specialized meteorological services. The initiation of these reports arises from a reexamination of the Foundation's programs and not from any significant increase in the amounts provided for that research. No increase is anticipated in these programs in FY1981 as opposed to FY1980.

AGENCY OPERATIONAL COSTS BY FUNCTION.

Table 2 shows how the agencies plan to obligate their FY1981 funds for the five major operational functions involved in meteorological service operations. A brief description of the activities included in each of these major functions is provided for a more detailed understanding.

Observations

This function involves obtaining data that define the physical and sensible states of the atmosphere. These data underlie all weather forecasts and warnings as well as supporting aircraft and ship operations. The observing function is divided into five program elements for planning and coordinating Federal Meteorological operations.

These are: surface, upper-air, weather reconnaissance, weather radar and operational environmental satellite observing programs.

Analyses and Forecasts

The analysis and forecast function involves centralized production of manual and computerized analyses of meteorological data as well as projections of the future states of the atmosphere and accompanying weather phenomena. For purposes of planning and coordinating programs, this function is divided into three parts:

- Analyses and forecasts on a global and hemispheric basis are prepared in Primary Centers;
- Products of Primary Centers are tailored for specific areas or user groups by area or guidance centers, and
- Specific weather phenomena, such as hurricanes and severe thunderstorms, are dealt with by specialized centers.

Communications.

Meteorological operations require moving very large amounts of data and information from the observation sites to the processing centers and then disseminating products to users. The communications function cost includes all costs for all types of communications equipment and services used for these purposes.

Dissemination to Users.

This function represents the final step in preparing and delivering weather service products to the users. The field offices of DOC and DOD and the flight service stations of DOT are the principal program elements involved.

General Agency Support.

Operation of the Federal weather programs involves the planning, training, maintenance and management activities common to any large activity, be it in the government or private sectors. Many of these activities are particularly demanding for weather service operations because of the highly dispersed field office structures and the need for very high levels of operational reliability. For purposes of planning and coordinating Federal Weather activities, the general support function is divided into: internal support and planning, engineering and mission-related work, maintenance of equipment and facilities, training of personnel and overall program management.

Table 2 shows that the agencies devote about 35% of their resources to observations on a sustaining basis. The principal changes year-to-year are associated with cyclic variations in satellite procurements and in costs for new equipment such as automatic weather observing stations and weather radars. Approximately 19% is devoted to analyses and forecasts where the major year-to-year changes are the result of replacing the computers that are the keystone of the operations. Communications costs, comprising about 10% of the total program, are usually stable year-to-year, reflecting the long term nature of communications systems planning, engineering and operation. The dissemination to users function is also usually stable from year-to-year at about 15% because the field office structures are not subject to large changes. General Agency support requiring the remaining 21% is subject to some significant year-to-year variations, especially in maintenance and training activities.

AGENCY	OBSERVATIONS		ANALYSES AND FORECASTS		COMMUNICATIONS		DISSEMINATION TO USERS		GENERAL AGENCY SUPPORT		TOTAL	
	FY80	FY81	FY80	FY81	FY80	FY81	FY80	FY81	FY80	FY81	FY80	FY81
Agriculture							750	776			750	776
Commerce	100948	111667	87248	91094	10344	10877	43928	44889	69593	71501	312061	330028
Defense	92119	106007	35277	45641	25379	24306	37521	39006	58773	61748	249069	276708
Energy	1223	1358	314	349	31	35	220	244	1348	1499	3136	3485
Transportation Coast Guard	372	350			187	175	39	39	642	787	1240	1351
Transportation FAA	19051	29376			34398	34659	32082	30881	19409	21725	104940	116641
EPA									500	500	500	500
NASA	60	62	303	364	67	62	8	8	352	288	790	784
NSF	Not Applicable											
TOTAL	213773	248820	123142	137448	70406	70114	114548	115843	150617	158048	672486	730273

TABLE 2
AGENCY OPERATIONAL COSTS, BY FUNCTION
(Thousands of Dollars)

AGENCY SUPPORTING RESEARCH COSTS

Table 3 shows how the agencies plan to obligate their funds for supporting research in the four functional areas used for planning and coordinating programs.

The supporting research functions do not differ greatly from those discussed previously for operational programs. The observation and dissemination functions are identical and the "Description and Prediction" function equates to "Analyses and Forecasts". The research function of "Systems and Support" covers the development and engineering research work related to maintenance, training and engineering operations.

Supporting research programs characteristically are stable year-to-year unless a major project is initiated or terminated by one or more of the agencies.

AGENCY	OBSERVATIONS		DESCRIPTION AND PREDICTION		DISSEMINATION		SYSTEMS AND SUPPORT		TOTAL	
	FY80	FY81	FY80	FY81	FY80	FY81	FY80	FY81	FY80	FY81
Agriculture	1354	1354	4400	4400	1016	1016			6770	6770
Commerce	8207	10517	11802	13264			3831	3823	23840	27604
Defense	33803	26151	12317	12565	1410	1765	8775	10865	56305	51346
Energy	Not Applicable									
Transportation Coast Guard	Not Applicable									
Transportation FAA	2120	3347	640	470	5048	6175	4629	3233	12447	13225
EPA			8000	8000					8000	8000
NASA	5910	5116	12300	13600	900	1800	31300	51800	50410	72316
NSF			700	700					700	700
TOTAL	51394	46485	50169	52999	8374	10756	48535	69721	158472	179961

TABLE 3
AGENCY SUPPORTING RESEARCH COSTS BY FUNCTION
(Thousands of Dollars)

METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH BY SERVICE.

Table 4 shows how the agencies plan to obligate funds for Basic and Specialized meteorological services and corresponding supporting research in FY 1981.

To assist in understanding this table, the following brief definitions of basic and specialized services are provided:

BASIC SERVICES. All activities that are possible within the given state of meteorological science required to produce or complete a description in time and space of the atmosphere. In general, the products of this process are meteorological in nature and are not necessarily useful in such form for the operational needs of users. These services also include those activities required to derive from raw data the products needed by the general public in their normal everyday activities and the protection of their lives and property.

The general functions involved in providing basic meteorological services include:

(1) Measurement of the meteorological characteristics of the atmosphere made with sufficient density and frequency to meet the needs of the general public and the common needs of all users.

(2) Collection of these measurements for processing.

(3) Analyses and prognoses of meteorological variables and interpretation of the analyses and prognoses for meeting the needs of the general public.

(4) Distribution of these meteorological analyses and prognoses to outlets for subsequent interpretation for the operational needs of all users, and the distribution and display of operational products to meet the needs of the general public.

	BASIC		AVIATION		MARINE		AGRICULTURE & FORESTRY		GENERAL MILITARY		OTHER		TOTAL	
AGENCY	OPNS	SUPP RSCH	OPNS	SUPP RSCH	OPNS	SUPP RSCH	OPNS	SUPP RSCH	OPNS	SUPP RSCH	OPNS	SUPP RSCH	OPNS	SUPP RSCH
Agriculture							776	6770					776	6770
Commerce	294885	25999	24071		3381	1530	6852	25			839		330028	27604
Defense	39873		158166	1732	9034	3828			45038	50786	24597		276708	56346
Energy											3485		3485	
Transportation Coast Guard	899				452								1351	
Transportation FAA	9318		107323	13225									116641	13225
EPA											500	8000	500	8000
NASA		72316									784		784	72316
NSF		700												700
TOTAL	344975	85915	209560	15007	12867	5358	7628	6795	45038	50786	30205	8000	730273	184961

TABLE 4
METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH
BY SERVICE FOR FY 1981
(THOUSANDS OF DOLLARS)

SPECIALIZED SERVICES: Those activities, derived generally from the output of the basic meteorological services, which produce those products needed to serve the operational needs of particular user groups. These user groups include, among others: aviation, agriculture, commerce and military.

(1) The general functions involved in providing these services include:

- o Establishing parameters needed to serve solely a particular operational purpose.
- o Collecting data from specialized measurements which conform with the established parameters.
- o Analyzing the data obtained from specialized measurements.
- o Interpreting the analyzed data and making prognoses to meet the operational needs of users.
- o Distributing and displaying these specialized products to meet the needs of individual users or groups.

(2) For purposes of Federal planning and coordinating, Specialized Services are:

- o Aviation Meteorological Services: Those services and facilities established to meet the requirements of general, commercial and military aviation. Civil programs which are directly related to services solely for aviation and military programs in support of land-based aviation and medium- or long-range missile operations are included.
- o Marine Meteorological Services: Those services and facilities established to meet the requirements of commerce and defense on the high seas, coastal and inland waters and for boating activities in coastal and inland waters. The civil programs which are directly related to services solely for marine uses and military programs supporting fleet, amphibious and sea-borne units (including carrier-based aviation and fleet missile systems) are included.
- o Agriculture and Forestry Meteorological Services: Those services and facilities established to meet the requirements of the agricultural industries and Federal, State and local agencies charged with the protection and maintenance of the Nation's forests. The agricultural, large-area crop inventory programs and fruit-frost programs of the Department of Commerce are included.

- o General Military Meteorological Service: Those services and facilities established to meet the requirements of military user commands and their component elements. Programs and services which are part of Basic, Aviation, Marine or Other Specialized Services are not included here.

- o Other Specialized Meteorological Services: Those services and facilities established to meet requirements of user agencies or groups not included in the preceding categories, such as support to: civil and military programs involving space operations; Federal, State and local governmental agencies responsible for dealing with urban air pollution; schools or training programs; R&D in areas other than space; and small agency programs for services. Department of Energy programs for these specialized meteorological services are included.

AGENCY STAFF ENGAGED IN WEATHER OPERATIONS.

Table 5 shows how agency staff resources are distributed among the five functions involved in weather operations:

Overall, agency staff resources in FY1981 are to decrease by 27 to a total of 18,551 personnel, an insignificant change. The largest changes among the agencies are planned by the Department of Defense with a decrease of 87 and by the Department of Transportation, Federal Aviation Administration, with an increase of 48.

Among the functions, "Dissemination" requires approximately 25% of all staff resources. This reflects the large number of field offices operated by the Department of Commerce, Defense and Transportation, with many of these offices operating around-the-clock to serve the general public, military needs and the aviation industry.

The functions of "Observations" requires about 22% and "General Agency Support" accounts for about 23% of the staff resources for weather operations. Both are labor-intensive, particularly maintenance of increasingly sophisticated equipment and around-the-clock observations for forecasts, warnings and aircraft operations.

"Analyses and Forecasts" consume approximately 20% of the Federal staff resources for weather operations. This function, while requiring a substantial number of personnel, makes extensive use of computers and related automated processing systems to prepare a wide array of products employed by field offices to satisfy the needs of the public and specialized users of weather information. A significant portion of these staff resources are devoted to preparing and maintaining the computer programs necessary to produce new, more effective products.

The "Communications" function requires about 10% of the staff resources, the smallest percentage of any of the functions. This reflects the fact that communication has become less labor-intensive over the years as modern equipment came into use. It is important to note that the high percentage of the total Department of Transportation (Federal Aviation Administration) staff resources devoted to "Communications" is attributable to their operation of major communications systems which support the other agencies as well as the FAA.

THREE MILE ISLAND, PA, NUCLEAR POWER PLANT APRIL 1979

USAF ATMOSPHERIC SOUNDING SUPPORT TO NOAA AND THE NUCLEAR REGULATORY COMMISSION DURING THE 3-MILE ISLAND INCIDENT. HARRISBURG INTERNATIONAL AIRPORT, MIDDLETOWN, PA. MARCH-APRIL 1979

AGENCY	OBSERVATIONS		ANALYSES AND FORECASTS		COMMUNICATIONS		DISSEMINATION TO USERS		GENERAL AGENCY SUPPORT		TOTAL	
	FY80	FY81	FY80	FY81	FY80	FY81	FY80	FY81	FY80	FY81	FY80	FY81
Commerce	1382	1390	1805	1813	134	133	984	979	1370	1367	5675	5682
(1)	14	14	179						31	31	224	224
Defense	2369	2312	1027	1019	649	632	2172	2161	1372	1364	7589	7488
(2)	70	70	760	760	207	207	258	258	794	808	2089	2103
(2), (3)			11	11	1	1	3	3	2	2	17	17
Transportation Coast Guard												
(2)	35	33			18	16	4	4	39	48	96	101
Transportation FAA	293	297			871	859	1170	1144	541	623	2875	2923
(2)												
EPA									13	13	13	13
TOTAL	4163	4116	3782	3782	1880	1848	4591	4549	4162	4256	18578	18551

(1) Personnel funded by other agencies.
(2) Staff-years.
(3) Staff-years funded by other agencies.

TABLE 5
AGENCY MANPOWER ENGAGED IN WEATHER OPERATIONS BY FUNCTION

INTERAGENCY FUND TRANSFERS.

Federal agencies transfer funds to other agencies to pay for services that the receiving agencies can perform more efficiently and effectively. Table 6 shows the interagency fund transfers for FY1980. While specific amounts may vary from year-to-year, depending upon agency needs, the pattern shown in this table is essentially stable.

The most significant of the interagency fund transfers planned for FY1980 are discussed for each agency:

- Department of Commerce.

  (1) The Department of Defense will be reimbursed $4.3 million for costs of providing airborne weather reconnaissance of tropical cyclones and winter storms.

  (2) Reimbursement of the Federal Aviation Administration for communications services will total $1.9 million.

  (3) The National Aeronautics and Space Administration will be reimbursed $45 million for costs related to procurement and launch of NOAA operational spacecraft.

- Department of Defense.

  The Department of Commerce will be reimbursed a total of $1.3 million for data acquisition and archiving.

- Department of Energy.

  Reimbursable costs of $1.9 million will accrue to the Department of Commerce, principally for weather support services at the Nevada Test Site and at other National Laboratories.

- Department of Transportation.

  The Department of Commerce will be reimbursed $5.1 million, principally for meteorological support at Center Weather Support Units located with most Air Route Traffic Control Centers, and for research and development on meteorological equipment and prediction technology to support flight safety.

- Environmental Protection Agency.

  Research and development support related primarily to air quality will require transfer of $2.8 million to the Department of Commerce.

AGENCY		FUNDS	
Transferred from:	Transferred to:	Fiscal Year 1980	
		Operations	Research
Commerce	DOD	4346	
	DOT (FAA)	1906	
	NASA	44971	
Defense	DOC	1257	94
Energy	DOC	1877	
EPA	DOC		2800
Transportation (FAA)	DOC	4713	432
	DOD		375
	DOI		105
NASA	DOC	316	200
	DOD	154	
	NSF		50

TABLE 6
INTERAGENCY FUND TRANSFERS FOR METEOROLOGICAL
OPERATIONS AND SUPPORTING RESEARCH, FY 1980
(Thousands of Dollars)

LOCATIONS BY OBSERVING TYPE.

Table 7 clearly illustrates the large number of weather observing operations carried on by Federal agencies. The only significant changes from FY1980 to FY1981 are the reduction in the number of Department of Transportation (U.S. Coast Guard) surface observation sites as eight more of their light stations are automated. The operation of two new local warning weather radars is planned by the Department of Commerce at Jackson, KY, scheduled for August 1, 1980; and at Beckley, WV, where a site-survey is being conducted.

OBSERVATION FUNCTION	AGENCY	FY 1980	FY 1981
Surface (land).....	Commerce	517	517
	Defense (U.S.)	141	141
	Defense (overseas)	85	85
	Energy		
	Transportation (FAA)	370	370
	Transportation (Coast Guard)	133	125
Surface (Marine).....	Commerce (MSCP)*	2000	2000
	Transportation (CG ships)	73	75
	Defense (ships w/met personnel)	31	31
Upper Air (Rocket).....	NASA	1	1
	Defense	9**	9**
Upper Air (Balloon).....	Commerce (U.S.)	70	70
	Commerce (overseas)	29	29
	Defense (fixed) (U.S.)	8	8
	Defense (fixed) (overseas)	11	11
	Defense (ship)	28	28
	Defense (mobile)	38	38
	NASA (U.S.)	3**	
	Transportation (Coast Guard)	19***	19***
Weather Radar.....	Commerce (U.S.)	122	124
	Defense (U.S.)	108	108
	Defense (overseas)	22	22
Weather Reconnaissance.....	Defense (# of aircraft)	20	20

* MSCP = Merchant Ships Cooperative Program
** On call basis, no regular schedule
*** Balloon support facilities inactive but available for use

TABLE 7
LOCATIONS BY OBSERVATION FUNCTION
FISCAL YEARS 1980 AND 1981

Section 3

FEDERAL PLANNING AND COORDINATION

Since Federal Plans play a major role in the activities of the office of the Federal Coordinator, it is worthwhile to discuss the issues involved in the planning and coordination process. As a general rule, Federal Plans are proposed for each of the specialized meteorological services and for meteorological programs common to two or more agencies. In most cases, the preparation of Federal Plans is facilitated by the existence of individual Agency plans for the service or program involved. The Federal Coordinator compiles input from the involved agencies and proposes a unified plan for consideration. More will be said on this subject later in this section.

In addition to specialized plans, which are developed as required, the office of the Federal Coordinator publishes the following plans annually:

- Federal Plan for Meteorological Services and Supporting Research
- World Weather Program Plan
- National Hurricane Operations Plan
- National Winter Storms Operations Plan
- National Severe Local Storms Operations Plan

The Federal Plan for Meteorological Services and Supporting Research, as indicated in the Preface, is required by Section 304 of Public Law 87-843. In connection with the budget presentation for each fiscal year, the Congress is provided with a horizontal budget showing the totality of the programs for meteorology.

The World Weather Program Plan is required, pursuant to Senate Concurrent Resolution 67 of the 90th Congress, to present to the President a consolidated estimate of the United States participation in international meteorological programs.

The National Hurricane Operations Plan, updated on an annual basis, presents procedures agreed upon by the U.S. Departments of Commerce, Defense, and Transportation, for providing warning services on Atlantic and Pacific hurricanes. The service is an interdepartmental joint effort to provide the Nation and designated international recipients with environmental data, forecasts, and assessments concerning tropical and subtropical weather systems.

The National Severe Local Storms Operations Plan, updated annually, describes the responsibilities, roles, and procedures followed by the U.S. Departments of Commerce and Defense, and the Federal Aviation Administration, in observing, forecasting, and communicating information on severe local storms over the United States.

The National Winter Storms Operations Plan identifies agency responsibilities in acquiring weather information for use in predicting and providing adequate and timely warnings of severe and crippling winter storms along the east and Gulf coasts of the United States. Agencies involved are the U.S. Departments of Commerce, Defense, and Transportation. The Plan covers the period November 1 to April 15 each year, since a relatively high incidence of winter storms is expected in that period, and it is updated on an annual basis.

In the past, (1964 to the present), Federal planning has concentrated on the publishing and the internal integrity of the documents mentioned and devoted few resources to coordination of multiagency programs. There has been general reluctance on the part of Federal agencies to consider ceasing a particular function and relying on its accomplishment by another Federal agency. However, the costs for operational weather programs are increasing rapidly, and cooperative efforts are now the rule rather than the exception.

Recent events have stimulated renewed Federal interest in the coordination and strengthening of the overall Federal weather program which is carried out within many Federal agencies. In the review of the natural resources programs of the Federal government, the President's Reorganization Project noted that some efficiencies and savings might result from the consolidation or integration of some weather programs. The General Accounting office report LCD-80-10, "The Federal Weather Program Must Have Stronger Central Direction", October 1979, urged more centralized planning and direction for Federal Weather service activities. The Office of Management and Budget undertook cross-cutting budget reviews for selected weather programs in the FY1978, FY1980 and FY1981 budgets in order to assure coordinated effort among the agencies involved.

As a result of this increased interest, increased staff and other resources will be provided for the future activities of the Office of the Federal Coordinator. These increases will, in general, be provided by the Federal agencies with major weather programs such as the Departments of Commerce, Transportation and Defense. In addition to providing an ongoing focus for the coordination of interagency weather programs, the increased capability in the office of the Federal Coordinator will be used to conduct studies and assessments that are responsive both to the needs of the Executive Branch and to the needs of the Congress.

The cross-cut analysis of agency proposals for surface weather observation automation, and the cross-cut analysis of agency proposals for next-generation weather radar are two efforts that have recently been completed by the Office of the Federal Coordinator. These analyses set the stage for comprehensive, coordinated, interagency implementation of activities in these very significant weather areas.

In fiscal 1980, the Office of the Federal Coordinator started a review of the operational capabilities of the three meteorological forecast centers that operate within the Federal Government. These centers, operated by the National Weather Service, the Navy and the Air Force provide basic services, but have been justified on the basis of the special requirements that each much satisfy, and to assure redundancy in case of failure at one or other of the centers. A question that will be addressed is the degree of consolidation that might now be cost-effective. The Federal Coordinator has also begun a review of Federal agency roles, missions and programs.

There are a number of Federal weather activity issues which should be addressed in Fiscal Year 1981 and subsequent years. Some relate to shorter term "duplication" matters, more effective use of resources, or coordination of plans that come into consideration during annual budget reviews. Others relate to fundamental issues of the Federal Government's policies with regard to weather services and associated research efforts.

The Federal Coordinator will begin to engage in analyses of a number of major policy issues facing the Federal Government in weather activities. The following areas represent the highest priorities and follow logically from the reviews of agency roles and missions and research and development discussed previously:

- o New weather services needs. What new weather services are going to be required by the Nation in the coming 10-15 years? Who will require them, and what benefits will they as a group and the Nation as a whole derive from them? How should these services be provided and how should they be financed? What R&D will be necessary?

- o The role of new technology in weather services. What new technology is or will become available in the next 10-15 years either to improve the quality of weather services or the efficiency of the programs? What actions are being taken or planned to develop this technology? What will it cost to develop and implement? What will be the benefits to users and to the government? How should it be financed?

- o Public and private roles. What are appropriate roles for Federal, state or local, and private sectors in providing weather services and conducting R&D? Which functions and services are clearly a Federal responsibility, which can be either Federal or other and which are clearly the province of the private sector? How should the Federal functions be financed? How should Federal costs be apportioned among the Federal agencies performing the services or deriving benefits therefrom?

To address these issues, the Office of the Federal Coordinator, has a number of evaluations and other studies in the planning stage or under consideration. Among these are:

(1) An assessment of the operational effectiveness of current and proposed realignments in regional and field structures in agencies providing weather services, to ascertain if realignment might increase effectiveness and reduce costs.

(2) An evaluation of the existing and planned weather information collection and dissemination telecommunications networks. As in the case of the computer processing centers, each agency involved in weather data transmission has, in the past, developed its own telecommunications network to satisfy its own requirements.

(3) An assessment of the overall manpower and training requirements during the next few years and the possible manpower sources to fill the needs.

Additional tasks under consideration for the Federal Coordinator are listed below:

1. Preparation of a detailed response to the comments and recommendations made in the GAO Report on central direction for the Federal weather program (on the communication of agricultural weather to users, and on the National Weather Service's role in providing specialized weather services). The GAO studies and reports provide information on the the GAO's perception of difficulties or areas where improvements might be made. The normal responses are often not detailed and it is uncertain that there is follow-up action to determine if the agency responses actually lead to useful changes (the OMB must be encouraged to provide sufficient resources for these activities to be accomplished - some can be done by means of personal services contracts - others must be accomplished by staff members in the office of the Federal Coordinator).

2. Prepare draft revisions to OMB Circular A-62 for consideration by OMB.

3. Undertake a comprehensive study of overall Federal requirements for weather observations before the generation of an implementation plan for the establishment of automatic surface observing stations.

4. Develop a data base upon which to build answers to such questions as:

   a. Are agencies maintaining or developing capabilities to satisfy their own needs without considering the capabilities and requirements of other agencies?

   b. Just how much redundancy or duplication is there among weather services provided by NWS, Navy and AWS, and is that which exists necessary?

5. Develop a schedule for inputs from the agencies on their weather services program in sufficient time for working with the OMB to influence the program.

6. Identify ambiguities that should be removed from current directives, and clearly define the weather services that are authorized by current statutes, authorities and responsibilities.

7. Assess the need for the Federal provision of enhanced weather services during the next 10 to 15 years.

8. Undertake a comprehensive review of the role of the Federal Government in providing specialized weather services. What should be the role of the private meteorological industry in providing such services?

9. Conduct a technology assessment on the impact of likely technological developments that might improve the quality and reduce the cost of providing weather services.

10. Preparation of issue papers and decision memoranda for consideration by the Federal Committee for Meteorological Services and Supporting Research.

Section 4

NATIONAL CLIMATE PROGRAM

The National Climate Program was established in 1978 by Public Law 95-367 as a means to assist the country and the world "to understand and respond to natural and man-induced climate processes and their implications." The program, one of research and applications, requires coordinated efforts among the many agencies that develop climate understanding and knowledge, that use climate information in accomplishing their particular mission, and that are responsible for the active dissemination of climate information to promote its utility to Government industry and the public.

P.L. 95-367 requires a five-year Plan to "establish the goals and priorities for the Program" and provide details on Agencies roles, funding requirements and expected Program achievements. The five-year Plan is prepared by the National Climate Program Office, A discussion of the program is included here for information only. The five-year Plan is intended as a guide (1) for Federal agencies, as they develop and manage their specific, mission programs; (2) for the research community, as the context for their studies; (3) for the private sector meteorologists and climatologists, as the source of information on Government activities that affect the availability of climate data and information products; (4) for Congress, as it exercises its oversight, authorizing and appropriating functions; and (5) for State and local governments, as they coordinate their own activities.

The National Climate Program totals, for FY1980, 122 million dollars. Four agencies -- USDA, DOC (NOAA), NASA, and NSF -- account for three-fourths of the total. The greatest strength of the present program is in research, where extensive international collaborative efforts have supplemented active programs in many Federal laboratories and academic institutions. Important satellite experiments are being funded to support further aspects of this research. Program activities in assessing the impacts of climate are also receiving additional attention in the present Fiscal Year. This is particularly true in the Departments of Agriculture and Energy.

The strategy that has been adopted for the National Climate Program is to emphasize early production of useful outputs on the basis of our research knowledge of climate while simultaneously expanding the understanding of climate and its relationship to society. This strategy is consistent with the purposes of the National Climate Program Act. It is the basis for the selection of particular emphasis and priorities for the Program.

The Plan defines three important areas where special emphasis will be given over the next five years. These areas are:

- o Providing climate products
- o Responding to impacts and policy implications of climate
- o Understanding climate

Within each area two levels of priority activities are described. The highest priorities are the Principal Thrusts of the program, each a multidisciplinary, multiagency effort for which a lead agency has been designated. Areas of Program Concern, the second level of priority, are additional efforts that warrant attention during this planning cycle.

The Plan also includes a description of the full range of Climate Program activities for which continued support is necessary to meet future contingencies. The attention given to the priority efforts does not imply neglect of the continuing basic program.

1. Providing Climate Products.

The Principal Thrusts are:

- o Generation and Dissemination of Climate Information. This effort, with NOAA as the lead agency, is designed to accelerate the flow of useful information to users. Obstacles that have impeded the availability of data and its flow in the past are to be removed. New institutional arrangements among users, State climate offices, Federal agencies, and independent climate experts are to be established so that the full value of climate information can be realized. A necessary first step is the evaluation of the required structures for these institutional arrangements.

- o Climate Prediction. This effort includes the development, testing and implementation of techniques for improved monthly, seasonal and interannual predictions. The lead agency is NOAA, with major developmental participation by the non-Federal sector through the establishment of experimental climate forecast groups. Over the next five years, modest improvements in the skill of climate forecasts appear possible. There are now a number of well-conceived approaches which warrant further development and careful testing and evaluation.

The areas of Program Concern in this category are Global Precipitation and Surface Climate Data Networks. The first one includes studies that could lead to better estimates of global amounts and locations of precipitation. The second is concerned with assuring the adequacy of the observational networks throughout the country that are used to collect the data for regional studies of climate and its impacts.

2. Impacts and policy implications of climate.

The Principal Thrusts are:

- CO_2, Environment and Society. Atmospheric carbon dioxide is inexorably increasing and there is a scientific concensus that the increase will continue and will cause climate changes. There is great urgency to learn when these effects will occur and what they will be, but even more important is assessing the potential social and economic consequences. Because the increase of CO_2 is associated primarily with the burning of fossil fuels, this Principal Thrust is under the leadership of the Department of Energy. This thrust includes studies to determine the nature, strengths and locations of the climatic effects. Investigations of physical and chemical systems to understand the rate at which these changes will occur, and studies of the impacts of these changes on the environment and on our societal system. At the end of the five-year period covered by the Plan, a major assessment of the state-of-knowledge and the policy options available for future planning will be completed.

- Climate and World Food Production. The Department of Agriculture will lead an effort to understand the impact of climate variations on world food production, and how to utilize that information to make better decisions on production, trade, management and allocation. Climate information will be incorporated into analyses and forecasts involving livestock and fisheries production so that decisions on food and agricultural policy can be made to stabilize world food stocks and supplies.

There are six Areas of Program Concern associated with this category:

- Climate-related Hazards, which include studies of the mechanics of natural hazard processes, and efforts to understand the societal implications of natural hazards and the societal responses to hazard events and hazard information.

- Energy Production, Distribution and Demand, efforts to quantify the relation between climate and energy demand, to learn better how climate affects various systems for energy production and distribution, and to understand the constraints and opportunities that climate implies for alternative energy sources such as wind, ocean waves and currents, and the sun;

- Impact Assessment Methodologies, the development and testing of a variety of tools and methods that can be used for assessment processes that support national policy and program decision-making;

- Regional Climate Effects of Man, studies and observations of the physical and chemical processes (such as the particulate-caused Arctic haze) that could lead to regional climate changes, and the nature and effects of those changes.

- Semiarid and Arid Lands, efforts designed to measure the effects of climate fluctuations and extremes (including droughts) on the productivity of these lands, and the study of climate information needs for the effective management of arid lands;

- Water Resources Management and Planning, studies to assure that climate data and information needed for management and design decisions are available, and that decisions in this area incorporate full utilization of knowledge of climate.

3. Understanding Climate.

The two Principal Thrusts are:

o Solar and Earth Radiation. This effort, led by NASA, is designed to elucidate the processes by which the climate system gains and loses energy. Our knowledge of the stability of the climate's solar energy source, and our understanding of the varying means by which the Earth redistributes energy and emits it back to space will be advanced substantially over the next five years. The simultaneous observations of the different components of this radiative exchange will lead to improvements in climate models that relate cloudiness and temperature variations to the radiation budget, and to improvements in our knowledge of the relationships between solar variations and climate fluctuations.

o Ocean Heat Transport and Storage. This Thrust, led by NSF, signals the start of a major, coordinated international

effort designed to increase our understanding of the ocean's role in climate. The oceans redistribute energy within the climate system, and exercise a large measure of control over the behavior of the entire system. During the five years covered by the Plan, there will be major advances in learning how to make large-scale measurements of ocean currents and temperatures, and understanding of ocean-heat transport and storage. This is an activity that is attracting a great deal of international scientific interest. A series of major international experiments are likely to evolve in the latter half of this and in the next decade.

There are five Areas of Program Concern in this category:

- Air Sea Interaction, studies designed to understand those large-scale interactions by which the two major components of the climate system are coupled;

- Climate Model Development and Validation, a continuing effort to develop improved models of the climate system is a basic integrating force of climate understanding as well as for prediction and sensitivity studies, and requiring large investments in talent and facilities;

- Past Climates, encompassing a variety of studies designed to provide knowledge of climate regimes not recorded by our limited instrumental record, contributing to our understanding of climatic changes, and providing important information for testing climate models;

- Polar Ice and Snow, efforts to increase our understanding of the role of Polar regions both as a part of the climate system to which other parts must accommodate, and as a sensitive indicator of climate change.

- Stratospheric Processes, the monitoring and research designed to provide increased understanding of stratospheric chemical and physical processes, and to detect climatically significant changes, e.g. ozone depletion.

In addition to a description of the scope of activities that comprise the Climate Program and a detailing of the priority efforts required for progress, three "special aspects" are discussed in the Plan. They are:

- o International Activities.
- o Intergovernmental Climate Program.
- o Experimental Climate Forecast Centers.

International Activities.

International cooperation in climate-related matters is a cornerstone for the National Climate Program. Cooperation is essential in collecting and disseminating data, in undertaking research and in assessing climate impacts, and the United States cannot manage the efforts alone. The World Climate Program, consisting of subprograms in research, impact studies, data and applications, is the major vehicle for such cooperation. Many international bodies have joined in this effort, including the United Nations Environment Program and the International Council of Scientific Unions.

A number of specific activities are presented in the Plan which the U.S. National Climate Program will contribute to the World Climate Program. These activities involve ocean research, climate prediction, international concern for CO_2, assistance to developing countries in applied climatology, and others. The U.S. will also engage in bilateral climate cooperation that is consistent with the goals and programs of the World Climate Program.

Intergovernmental Climate Program.

The Act directs the establishment of a program for Federal and State cooperative activities in climate. The Plan outlines a phased development of this program as an integral part of the Principal Thrust in Generation and Dissemination of Climate Information. The functions of the cooperative efforts emphasize the availability and use of local and regional climate information. The first exploratory efforts to gain the knowledge for the design of the intergovernmental program and demonstrate its worth will begin in FY1980. These pilot studies will also lead to decisions on appropriate cost-sharing and allocation of functions between the Federal Government and the States. The full implementation of the program will depend on the outcome of these studies, but a plan is laid out by which full implementation would begin in FY1982.

Experimental Climate Forecast Centers.

The first experimental climate forecast center will be designated in FY1980 as part of the Program's Principal Thrust in Climate Prediction. The establishment of additional experimental groups is an option for future program development. Groups will be selected with a view to their potential for developing innovative approaches to prediction, including concern for adopting predictions to particular applications of climate information, like energy or agriculture. The experimental forecast centers will also be involved in research on how to improve verifications of climate predictions.

The Program will be administered by the National Climate Program Office with the help and guidance of several interagency bodies, the Climate Program Advisory Committee which has been established by the Secretary of Commerce, and other outside advisory groups. The Office will work closely with the several Agencies and the Office of Management and Budget in preparing and analyzing specific budget proposals to implement the Plan.

Associated with each of the Principal Thrusts, and with some of the Areas of Program Concern, are options for future program development -- activities for Fiscal Years 1982 through 1984 for which specific budget commitments have not yet been made. The Plan establishes a priority ranking for those options, all of which should be given careful consideration in developing future budget proposals. The highest priorities are assigned to options associated with the following:

- o Generation and Dissemination of Climate Information, and
- o Climate Prediction

followed by:

- o CO_2, Environment and Society

4. Agencies' Request

For 1981 the agencies have requested a total of $136M (see Table 8)--an increase of $13M (11%) over the 1980 estimated funding level of $123M. The major program expansions proposed for FY 1981 are as follows:

- o Impact Assessment. The 1981 request is for $26M, an increase of $3.0M (13.0%) over the 1980 level of $23M. The increase is almost totally for the Department of Energy with emphasis on the possible impacts of climate change caused by increasing carbon dioxide (CO_2). In addition, the impacts of climate on energy demand and of energy development on climate are being assessed including the effects of aerosols and clouds on the solar radiation received at the ground.

- o Climate System Research. The 1981 request is for $38M--an increase of $7M (26%) over the 1980 level of $31M to conduct fundamental studies, including modeling efforts, of all aspects of climate and climate change. NASA, DOD and DOI will continue at approximately the same level as for 1980. The increases are largely for oceanic research. DOC requests an increase of $2.7M over FY1980 to support ocean studies. NSF requests an increase of $2M for air-sea interaction, ocean heat storage and

transfer and carbon dioxide-related research (coordinated with DOE). DOE requests an increase of $3.3M primarily for increased studies of the global carbon cycle and modeling of possible effects of carbon dioxide increases. The two topics of heat storage and transfer in the oceans and the climatic consequences of carbon dioxide buildup in the atmosphere represent the major thrusts in the 1981 program.

- o Observations and Monitoring. This request to support climate-related observations in atmosphere and oceans is again the largest component of the program. The 1981 request is for $49M--an increase of $2M (4%) over the 1980 level of $47M. The increase is primarily requested by NASA (a total of $32M) to support preparations for the Earth Radiation Budget Experiment (ERBE) and for stratospheric monitoring.

- o Data Management. The 1981 request of $16M represents no increase over the 1980 level. DOC has the largest request of $6.4M, largely for the activities of the National Climate Center.

- o Analysis and Prediction. This category covers efforts to analyze climate data and to develop its use for forecasting. The 1981 request ($3.6M) is marginally below ($0.3M) the 1980 request. The DOC request ($2.2M) is to continue support for the Climatic Analysis Center. USDA ($1.2M) is involved in predictions of water availability. NSF ($0.2M) supports research on prediction techniques.

- o Information Services. No increase over 1980 is requested in the 1981 level of $2.8M. DOC ($2.0M) has the responsibility for providing general climate information to the public. DOI and USDA provide some climate related information.

- o National Program Management. DOC requests an increase of $0.4M (over the 1980 level of $0.6M) for a 1981 level of $1.0M. This is the operation of the National Climate Program Office and to support its development of an experimental climate forecasting center, assessments of state climate information services and demonstrations, and regional impact assessment studies.

	USDA	DOC	DOD	DOE	DOI	NASA	NSF	TOTAL
Impact Assessment	12.4	0.8	4.6	6.3	0.9		0.8	25.8
Climate System Research		7.2	1.0	7.2	1.5	3.0	18.1	38.0
Observations and Monitoring	2.6	4.9				31.5	9.5	48.5
Data Management		6.4	3.5		3.3	1.5	1.2	15.9
Analysis and Prediction	1.2	2.2					0.2	3.6
Information Services	0.6	2.0	0.2					2.8
National Program Management		1.0						1.0
TOTAL	16.8	24.5	9.3	13.5	5.7	36.0	29.8	135.6

TABLE 8
FISCAL YEAR 1981 CLIMATE PROGRAM BUDGET REQUEST SUMMARY
(Budget Authority $M)

APPENDICES

NOTE:

These are a compilation of statements submitted to the Office of the Federal Coordinator by the Agencies on the status of their weather programs.

APPENDIX A

DEPARTMENT OF AGRICULTURE

The Science and Education Administration's (SEA) research efforts relate directly to climatic effects and deal with developing technology and systems such as: 1) management of precipitation and solar energy for optimum crop production; 2) the understanding and management of water resources for agricultural use; 3) the mechanics of the water-plant-atmosphere interactions; 4) optimization of the use of energy, water, and fertilizer; 5) reduction of plant and livestock losses from pests; 6) improvement of techniques for irrigation and drainage; 7) reduction of plant and livestock stress from the environment; and 8) development of production, management, decision, and tactical models and systems to minimize the adverse effects of climate and weather.

Studies are being performed to determine the action of air pollutants on plants and methods of controlling the damage. SEA is cooperating with State and Federal agencies and universities to establish a nationwide program for monitoring deposits of atmospheric pollutants to determine their extent and effects on agriculture and natural ecosystems.

The Forest Service is continuing its program of meteorological supporting research, with emphasis on weather effects on forest fires and air quality. Research is pointed toward supporting Federal and other land managers by providing information for fire and smoke management, for prevention of significant deterioration of air quality and related values, and by studying the mechanisms by which mountainous terrain affects meteorological conditions.

Investigations carried out by the Economics, Statistics, and Cooperatives Service will determine the potential economic effects of weather on crop production, both domestic and foreign. One aspect of these studies is the development of models relating various weather parameters to crop yields. Econometric and simulation models of weather-crop-yield interactions, together with other variables affecting crop yields, are constructed for use in economic analysis, including short-run forecasting and long-range projections.

APPENDIX B

DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL WEATHER SERVICE (NWS)

INTRODUCTION.

This appendix describes NWS' purposes, mission, and major products and services, together with the system used to develop these products and services and to make them available to users. It shows NWS's major functions, the sequence in which they are performed, and the principal performing organization within NWS. It also shows the resources NWS devoted to these functions and the ways in which it measures their principal outputs.

MISSION - NWS's basic purposes are:

- To help ensure the safety and welfare of the general public with respect to weather conditions, including conditions involving natural disasters.

- To further the conduct of municipal, commercial, industrial and other activities which are affected by the weather, such as agriculture, aviation, transportation, construction, and energy transfer.

To fulfill these purposes, NWS:

- Observes and reports the weather, river and ocean conditions of the United States and its possessions.

- Issues forecasts and warnings of weather, flood and ocean conditions.

- Develops national meteorological, hydrologic, and oceanic service systems.

- Performs applied meteorological research.

- Assists community preparedness programs for weather-related natural disasters.

- Participates in international meteorological activities, including exchange of data and forecasts.

BASIC ENABLING LEGISLATION AND AUTHORITY.

- Organic Act of 1890 created the U.S. Weather Bureau.
- Enabling Act of 1919 allowed U.S. Weather Bureau to enter into cooperative agreements for providing agriculture weather services.
- Flood Control Act of 1938 authorized the establishment, operation, and maintenance of the Hydroclimatic Network by the Weather Bureau for Flood Control.
- Federal Aviation Act of 1958 outlined duties of the Secretary of Commerce for provision of weather observations and services to aviation.
- OMB Circular A-62 established criteria for Federal provision of meteorological services and supporting research.

PRODUCTS AND SERVICES.

NWS produces two general kinds of products and services:

- Weather observations, forecasts and warnings, both scheduled and unscheduled, and consisting primarily of descriptions of current weather, river and sea conditions and predictions of future weather events and conditions.
- Technical advisory, and other ancillary meteorological and hydrological services.

Weather Observations, Forecasts, and Warnings include:

- General weather conditions, including sky conditions, temperature, wind, precipitation, visibility, pressure, tides and currents.
- Severe weather events such as hurricanes, other tropical storms, tornadoes, and thunderstorms.
- Hydrologic conditions, including river levels, flood levels, and flash floods.
- Marine weather, including coastal tides and currents, hazards to navigation on the high seas, conditions for pleasure boating, and ice and other factors affecting marine navigation.
- Tsunamis affecting the west coast of the United States, including Alaska, Hawaii, and United States territories in the Pacific.

- Aviation weather, including terminal and enroute weather advisories principally detailing type of precipitation, cloud ceilings and visibility, wind factors, and such significant enroute aviation hazards as aircraft icing, turbulence, and thunderstorms.

- Agricultural weather, including soil moisture and temperature, leaf wetness, evaporation, drying conditions, and other factors affecting farming and ranching.

- Environmental quality, including meteorological conditions affecting wildfire control, forest and range management, and air pollution levels.

- Weather conditions affecting such special activities as space flight operations, atomic testing, controlled burning to remove forestry wastes, and oil spills and other emergencies affected by the weather.

Dissemination of NWS's weather reports is accomplished principally through electronic means: radio, TV, telephone, teletypewriter circuits, and facsimile. However, some is through face-to-face contact or visual inspection of products by the using community. Four principal kinds of electronic systems used are:

- Systems involving the mass news media: radio, television, and the newspaper. These outlets are linked to the NWS primarily by Teletypewriter.

- Those involving other government agencies, primarily the Federal Aviation Administration (FAA) but also other Federal, State, and local agencies.

- Those involving heavy-duty telephone answering devices operated by telephone companies.

- The NOAA Weather Radio (NWR) System which provides continuous, direct access to the using community. In 1980, 344 stations nationwide were on the air.

NWS also performs a variety of other services, including:

- Disaster preparedness services

- Technical services for agriculture

- Voluntary Cooperation Program of the World Meteorological Organization (WMO)

- International meteorological and hydrologic advice and consultations

- o Climatological services
- o Litigation and expert testimony activities

BASIC FUNCTIONS.

NWS carries out four broad functions that are basic to the development and dissemination of its principal product group, which are weather reports. These are:

- o Data acquisition
- o Forecast and warning preparation
- o Communications
- o Applied research and development relating to the above

Data acquisition involves observation, collection, and some preprocessing of data on atmospheric, hydrologic, and oceanic conditions. Atmospheric data are by far the most important, accounting for more than 90 percent of the data acquisition budget and are further subdivided by type of observation:

- o Surface
- o Upper air
- o Radar
- o Satellite

Forecast preparation includes data processing and analysis, as well as development of predictive material. The function is subdivided by the scale and focus of this material.

- o Large-scale forecasting focuses on national and hemispheric weather and mostly produces guidance material for other forecasting.
- o Specialized forecasting areas which are determined by the nature of the specific conditions and the events being predicted and produces both guidance material and products intended for the user.
- o Medium scale forecasting focuses on State and multi-state areas, as well as zones within a State. It is the scale at which most products are issued to users.
- o Small-scale forecasting involves adaptations of medium-scale products to individual localities and communities.

The communications function divides into subfunctions:

- Internal communications involve the transfer and distribution of information within the meteorological community (i.e. communications between data acquisition points and forecast preparation centers and between preparation centers). This community includes NWS, other Federal agencies (such as FAA, Coast Guard, and the Department of Defense), the international meteorological organizations, and the private practitioners.

- External communications involve transmission of weather and river information to the public and specialized users. It involves the systems described in the preceding section: the media, FAA and other government agencies, commercial telephone systems, and the NWS broadcast system.

The functions above are carried out by the following principal organizational components:

- The National Meteorological Center (NMC) in Camp Springs, MD, makes large-scale forecasts and develops associated guidance material.

- The National Hurricane Center (NHC) in Miami, FL, and two regional centers in San Francisco, CA, and Honolulu, HI, are concerned with specialized forecasts and associated guidance for hurricanes and tropical storms.

- The National Severe Storms Forecast Center (NSSFC) in Kansas City, MO, is concerned with specialized forecasts and guidance for tornadoes and severe thunderstorms. NSSFC also provides aviation forecasts and advisories concerning severe convective activity.

- The 13 River Forecast Centers (RFCs) produce specialized river and flood level forecasts and guidance material. Each RFC covers a major national watershed or portion thereof involving several states.

- The 52 Weather Service Forecast Offices (WSFOs) prepare and issue medium- and small-scale forecasts and weather watches and warnings, and acquire meteorological data. There is essentially one WSFO per State.

- The 198 local Weather Service Offices (WSOs) issue small-scale forecasts and weather watches and warnings, and acquire meteorological data.

- There are 39 Weather Service Meteorological Offices (WMSO), 13 Weather Service Contract Meteorological Offices (WSCMO), and some 600 automated observing stations that acquire data.

The functions described above are performed in a sequence which, though occasionally modified, establishes the essentials of NWS' product flow. This sequence basically involves:

- Data acquisition
- Use of selected data to prepare large-scale forecasts
- Use of selected data and large-scale forecasts to prepare specialized and medium-scale forecasts
- Release of these forecasts to the user, either with or without further adaption to reflect small-scale conditions

Data Acquisition. The product sequence begins with the acquisition of data on atmospheric, hydrological, and oceanographic conditions for the United States and large portions of the rest of the world. Most of the data are collected by the NWS, FAA, NESS, the Department of Defense, weather services of other nations, and cooperative observers (the latter including both land and shipborne observers). Some of the data also come from the Soil Conservation Service, Forest Service, and the Geological Survey.

There are more than 1,000 principal surface observation points nationwide, with about 400 sites providing 24-hour service. Schedules at other sites are predicated on established needs, e.g., flight schedules. Most NWS observations are manually acquired by the WSFOs, WSOs, and WSCMOs, although NWS is in the process of automating selected sites through its automated meteorological observing system. Elements observed include cloud cover, temperature, dew point, wind speed and direction, atmospheric pressure, and precipitation type and amount. These principal sites are augmented by 12,000 land-based cooperative observers, who report daily temperature and precipitation amounts.

Many of these field stations also send balloon-borne meteorological instruments aloft to measure temperature, moisture, pressure, and wind to 33 km above the surface. A few rocket soundings reach 100 km. There are 140 observation sites within the United States and its territories, the Caribbean, Mexico, and Central and South America. Most sites take two upper-air soundings per day at the standard analysis times of 1200 GMT and 0000 GMT. These soundings are augmented by weather observations from aircraft in flight.

Specifically designed NWS weather radars monitor the location, extent, intensity, and movement of such severe or hazardous weather conditions as hurricanes, tornadoes, severe thunderstorms, and heavy snowstorms. Weather radars also are capable of qualitative

estimates of rainfall amount over specific watersheds, which aid the forecasting of river floods and flash floods. About 122 weather radars are operated by WSFOs, WSOs, and WSMOs. These are augmented by about 90 weather radars operated by the Department of Defense. Of the NWS radars, 56 are staffed and operated continuously.

NESS operates weather satellites which "see" cloud cover through visual and infrared photography. The Geostationary Operational Environmental Satellite (GOES) system is 36,000 km above the earth's surface. Its orbit is Earth-synchronous, i.e., always stationary over the same point on the Equator. The polar-orbiting NOAA satellites orbit the Earth from pole-to-pole. In both systems, the resolution or accuracy of locating clouds is very high, and these systems can also be used to infer cloud thickness, temperature distribution, and vertical distribution of wind.

Hydrologic data are collected at about 8,000 river points nationwide. Data measurements are made of river levels and precipitation amounts as input to prediction models that forecast river stages for 2,500 points. Some of these data are obtained automatically through NWS's Automated Hydrologic Observing System (AHOS).

Oceanographic data include "profiles" of deep ocean temperature and salinity, which are derived from bathythermographic measurements made by U.S. Department of Defense and U.S. research vessels. There are undersea measurements made at different depths. Sea-surface temperatures are observed and reported by NOAA data buoys, the U.S. Navy and American research vessels, as well as by ships-of-opportunity of many nations. Observations of tides, sea and swell are also observed and reported daily.

Forecast Preparation. Once acquired, the data are transmitted to all NWS organizations that have pertinent forecasting responsibilities. the organizations then process and analyze the data and use the results to prepare their respective outputs. Such organizations include the WSFOs, and WSOs, as well as the large-scale and specialized weather forecasting organizations that have major responsibilities for preparing guidance material for the WSFOs and (through the WFSOs) for the WSOs.

Preeminent among these organizations is the National Meteorological Center (NMC), which in many respects is the key to NWS's analysis and forecast function. NMC has responsibility for developing coordinated large-scale forecasts and associated guidance material for the United States and much of the rest of the Northern Hemisphere, plus portions of the Southern Hemisphere. It produces a large number and variety of graphic products describing both current and forecast conditions throughout these areas.

Current condition depictions include 3-hourly and 6-hourly pressure analyses at the surface and 12-hourly analyses at about 1.5, 5.6, and 10.4 km above the surface. Other current depictions include analyses of cloud cover, convective activity (thunderstorms and related phenomena), air stagnation potential, distribution of nationwide temperature and precipitation, and such atmospheric dynamics as instability, vertical motion, and freezing level variations. These products are produced by a mix of computerized numerical methods and human intervention to adjust for subjective considerations. They give forecasters throughout the Nation a generalized, three-dimensional appreciation of the current weather situation.

Using information on current conditions as a starting point, NMC then uses automated numerical means (based principally on simplified models of atmospheric dynamics) to predict future conditions of the Nation's weather for periods up to 10 days.

NMC transmits this entire body of information to forecasters throughout the Nation as guidance material for the preparation of specialized, medium-scale, and small-scale forecasts which become the final products issued to the using community. This information is distributed widely. NMC makes about 2,000 facsimile and teletypewriter transmissions daily to field forecasters. In addition, there are daily communications schedules for overseas users.

NMC's products are intended primarily to guide organizations responsible for specialized and medium-scale forecasts, and virtually all are made available to the public through these forecasts. A few products, however, are disseminated without change, either directly by NMC or through other NWS organizations.

Specialized forecasting covers a less-than-national area, either a variable area determined by the current and future condition of hurricanes, tornado systems, or other specific phenomena; or a fixed area determined by river and stream drainage. Forecasts of NSSFC and NHC fall into the first category; those of the RFCs into the second. All, however, share two common characteristics:

- They forecast only specific meteorological or hydrologic phenomena.
- Their products represent important guidance to the WSFOs and influence WSFO forecasts, but they typically also go to the user without change.

NSSFC prepares and issues tornado and severe thunderstorm "watches," which are then disseminated to the public in the threatened areas. A watch is a public-oriented statement which indicates that meteorological conditions are favorable for the

development of severe thunderstorms or tornadoes. The watch statement may include advice as to what precautions should be taken by the public to protect itself from these hazards. As opposed to a watch, a warning of severe thunderstorms or tornadoes can be issued by any NWS field facility when a thunderstorm or tornado has been sighted.

NHC issues bulletins describing the current and future location, intensity, and movement of hurricanes, other tropical storms, and associated coastal tides. These bulletins are considered final products and are issued either directly or through the WSFOs to the public and other interested groups without modification.

Just as NHC and NSSFC analyze and forecast hurricanes and other severe disturbances the RFCs develop specialized analyses and forecasts of river levels and flood stages to be expected in major national watersheds. They also develop runoff and snowmelt forecasts. RFC forecasts are normally disseminated to the public through the WSFOs without change.

Building primarily upon the material provided by NMC, the 52 WSFOs reanalyze and develop a large number of forecast products particularized and stylized in terms of area peculiarities and special user needs. These medium-scale forecasts often are issued directly to the public without further modification. A representative list of these products follows:

- State forecasts cover general weather conditions out to five days for a State or, for areas like New England where the States are small, a grouping of States. Information would include expected amount of sunshine or cloudiness, precipitation, diurnal temperature variations and wind conditions.

- Zone forecasts are similar in content to state forecasts but further particularized to an area generally comprising several counties or parishes.

- Recreational forecasts are similar to State forecasts, but limited to recreational zones, beaches and pleasure boating areas, skiing areas and so on.

- Agricultural forecasts reflect a further particularization of the weather elements included in a State forecast, to allow decision making by farmers in terms of spraying crops, irrigating, harvesting, and so on.

- Aviation forecasts again represent a further particularization of weather elements, so that the information applies to airport conditions and inflight weather.

- Marine forecasts are similar in content to State forecasts except that they focus on coastal and high-seas.

- Air pollution and fire weather forecasts particularize weather elements to express either the atmosphere's ability to dilute and disperse pollutants or the effect of weather elements on wildfires and wildlands management activities.

Small-scale forecasting involves the modification of medium-scale products so that they describe a specific locality, such as a city and its suburbs, an airport terminal, a national forest, a farming community, a local recreational area, a point-source polluting area, and space launch and recovery areas. This process considers two different sets of variables: (1) topographic and climatological peculiarities, in the case of local public weather-type forecasts, and (2) unique parameterization of the basic weather elements to make them useful for specialized activities. Examples of the latter would be spraying information for crop protection or estimates of fuel moisture content of the debris covering a national forest.

An aspect which tends to make these forecasts unique is that, unlike those described previously, they may or may not be made by professional meteorologists. Professional meteorologists at the WSFOs do, indeed, make small-scale forecasts, but they are also made by technicians at the WSOs. For this reason, they are frequently described as adaptive forecasts. They are not original products, but rather a repackaging and localization of products to meet localized needs. Areas without a WSO, locally situated WSFO, or NOAA Weather Radio coverage do not have access to such adaptations and use the applicable medium-scale forecasts instead.

Communications. Transmission of data from points of observation to forecasting centers, between such centers and within the meteorological community generally is the job of NWS's internal communications systems. These systems involve landline telephone, radiotelephone and microwave transmission. They make use of teletypewriters, facsimile equipment, telephones and specialized computers. The computers are used to perform various processing operations that facilitate transmission, particularly transmission of data to forecasting centers.

Besides its own system, NWS has access to and uses a number of communication systems maintained by the FAA, the DOD, and other government agencies. The FAA systems play a particularly important role, forming an integral part of the overall network.

NWS uses three principal groups of internal communications systems:

- Longline teletypewriter systems that are controlled by FAA and which handle much of NWS's observation data and many of its public forecasts.

- o NWS-controlled facsimile systems that are used for the transmission of forecast guidance material, as well as some data.

- o A special NWS system reserved largely for radar data and hurricane, tornado and flash flood and other storm or flood warnings, and marine data.

External communications -- the transmission of forecast information to users -- are characterized by systems which involve:

- o Government-operated teletypewriter systems to commercial TV and radio stations, e.g., NOAA's Weather Wire Service.

- o Direct radio broadcasts to the public through NWR.

- o Heavy-duty automatic telephone answering devices which are operated by the telephone companies, and which directly give the public weather information furnished by NWS stations.

- o Direct NWS-to-the-public telephones, including automatic answering devices at NWS field offices and personalized services.

- o Government and other intermediaries, e.g., Coast Guard radio telephone, FAA weather information disseminating systems, civil defense systems such as the National Warning System (NAWAS) and systems run by private communication industries such as RCA.

External communications is the principal effort to disseminate weather intelligence to the users -- the public, industry, and other specialized groups. The success or failure of this effort depends almost totally on the cooperation among NWS, other Government agencies, and private industry, especially the mass news media. NWS is capable of transmitting this information in a timely manner to the news media, but depends heavily on the news media for further transmission to the user. For this reason, NWS's current efforts are focused on the direct radio broadcasts described earlier. Examination of direct dissemination via public-service and cable television is also underway.

NWS views the present system for collecting, preparing and distributing weather information as too slow and cumbersome to permit optimum response to warning situations. It has been acceptable up to now, because the current system was limited by the state-of-the-art in communications technology. Now, the microprocessor has been adequately developed and NWS is proceeding to a new level of communication under AFOS (Automation of Field Operations and Services), which will shorten the time between the

recognition of hazardous weather and the issuance of warnings to the general public from between five and 15 minutes to as short a time as a minute or two in most instances.

Through AFOS, weather offices will be provided with off-the-shelf processing display and communication technology that will allow them to:

- Automate the routine duties of professional personnel.
- Provide automated assistance to the professional aspect of the forecasters' jobs.
- Communicate data to the forecaster and information to the news media over the computer-controlled circuits.

When fully implemented, AFOS will either replace or require large modifications in present communications systems.

Research and Development

To ensure that the quality of NWS forecasts and services continues to improve and is in line with current state-of-the-art, applied research and development is carried out in a number of areas.

- Numerical Prediction - Research and development is aimed at improving the day-to-day general forecasts and warnings and hurricane service by placing the analysis and prediction system on a stronger scientific basis. Numerical prediction models that simulate atmospheric and hydrologic processes are constantly worked on and better computer techniques to solve the underlying equations are developed. Long-range prediction research is aimed at developing improved forecast techniques, climatology and statistical analysis.
- Hydrologic Models - Research efforts concentrate on the improvement of specific facets of the NWS River Forecast models using meteorological information and forecasts. Studies, augmented by research contracts, involve dam-break flood forecasting, snowmelt, mechanics of the rivers and procedures to update river forecasts.
- Equipment Development - NWS conducts research to devise and develop new and improved techniques for measuring weather elements. Meteorological instrumentation is being developed with a primary emphasis on automating the detection and dissemination of the data. Integration of automatic sensing equipment with AFOS will allow for computer controlled collection and processing of observational data. Test and evaluation of weather equipment is conducted at

Sterling, Virginia. This facility which has the capability to simulate a typical weather station, conducts tests of equipment and procedures under a wide range of environmental and operational conditions.

- o Specific Products - NWS also conducts ad hoc research and development to improve quality and timeliness of forecasts and warnings issued to the public. Research and development is conducted in the Systems Development Office, the Hydrologic Research Laboratory, the Regional Offices, the National Hurricane Center, the National Severe Storms Forecast Center, River Forecast Centers and many WSFOs to improve the forecasts of hurricanes, severe local storms, general weather, general flooding, flash floods and aviation weather conditions, using both dynamic and statistical techniques.

OTHER FUNCTIONS.

Besides its three basic functions, NWS also carries out a number of other functions which are either:

- o Required to provide technical assistance and other services, or
- o Essentially supportive in nature.

This section identifies these functions and indicates the NWS organizational components that are mainly responsible for carrying them out.

Technical Assistance Functions. Besides developing and issuing weather reports, NWS provides a number of other services that essentially involve technical assistance, advice and consultation.

- o Disaster preparedness assistance is designed to improve the response by community officials and the public to forecasts and warnings. It is carried out with available resources by WSFOs, WSOs and warning preparedness meteorologists assigned to WSFOs primarily in the Eastern, Midwest, and Southern States. A Washington-based staff coordinates this program.
- o Technical assistance to agriculture involves four Environmental Studies Service Centers (ESSCs) in Texas, Mississippi, Alabama and Indiana. These ESSCs provide technical services both directly and through their respective land grant colleges.
- o The WSFOs and WSOs also provide direct technical assistance.

- The Voluntary Cooperation Program provides meteorological assistance to less developed countries.

- International meteorological and hydrologic advice, consultation and assistance is available upon request.

- NWS offices are involved in weather-related litigation activities and expert testimony.

- Climatological services are offered by the WSFOs, the WSOs, the RFCs and the ESSCs. NOAA's Environmental Data Information Service (EDIS) is also heavily involved, having the principal Federal responsibility in this area.

Support Functions. To operate and maintain NWS' various activities, substantial support functions are required. In common with other organizations, NWS requires a cadre of management and administrative personnel, but there is also more specialized support in a number of scientific and technical areas.

- Administration and management involves primarily national headquarters and NWS's six regional offices. Policy and procedural management is provided principally through the Weather Services Operations Manual.

- Engineering support involves facilities and equipment procurement, installation and management. Equipment maintenance and repair is a major item, involving some 450 electronics technicians deployed throughout NWS' field structure and more than 10 percent of the agency's total budget.

- Research and development includes efforts to improve forecast techniques, equipment systems and numerical weather prediction models, as well as equipment development and testing.

- Meteorological and hydrologic training is carried out by the NWS Technical Training Center in Kansas City, as well as under contract through universities and other Federal agencies.

NWS also draws upon support services provided by other Departments and NOAA components, particularly the Environmental Research Laboratories and the National Ocean Survey. These organizations provide research and map production services, respectively.

PERFORMANCE LEVELS.

NWS determines performance levels largely on an output basis, focusing on the basic forecasting subfunctions identified earlier. A key performance measure is accuracy, and NWS's national verification program determines accuracy measures for public weather and aviation forecasts for the NMC, the WSFOs and the WSOs. Within the WSFO's, accuracy is also determined on an individual basis. Similar verification programs are maintained for the NHC, NSSFC and the RFCs.

The primary purpose of NWS's verification program is to compare performance of these offices both over time, and one against the other. The program compares accuracy both in absolute terms and against the historical averages (climatology). Another purpose of the program is to determine the extent to which WSFOs improve on NMC forecasts.

ENVIRONMENTAL DATA AND INFORMATION SERVICE (EDIS)

Unless otherwise noted, EDIS authority for its activities is contained in 15 USC 313, 49 USC 1463 and Department of Commerce Executive Order 25-5B. EDIS disseminates global meteorological and climatological data and information to meet the needs of users in commerce, industry, agriculture, the scientific and engineering community, the general public and Federal, State and local governments. It also provides experiment design, data management and analysis support to national and international meteorological research programs. In addition, it assesses the impact of climatic fluctuations on yield of selected grain crops, energy demand and conservation and other environmentally sensitive activities.

The EDIS National Climatic Center (NCC) is the custodian of U.S. weather records and is the largest climatic data center in the world. It also disseminates environmental satellite data. In addition, NCC houses World Data Center-A, for Meteorology and Nuclear Radiation. NCC receives and processes millions of meteorological observations annually and makes data and related products available to a large, diverse, user community. Data are gathered from the National Weather Service, the National Environmental Satellite Service, military services and international sources to provide a National Climatic Data Base for multiple uses. More than 80,000 subscribers regularly receive published data.

NCC is working with other EDIS and NOAA components and the U.S. Department of Energy to quality control and validate solar radiation data taken in past years and combine them with other meteorological data in a form most useful for solar energy applications. NCC now can provide hourly solar radiation data or

estimates for 241 locations in the United States. These data are used to determine the availability of solar energy for heating, cooling, and power generation systems. The Department of Energy is using the reworked solar data to develop typical solar radiation values for selected U.S. cities.

About one-third of all the energy consumed in the United States is used to heat, cool and operate homes, apartments, offices and other buildings. It has been estimated that building-associated energy consumption could be cut by up to 40 percent if buildings were designed, sited and built by applying climatic data to minimize undesirable environmental effects and to maximize the impact of beneficial environmental elements. NCC and the American Institute of Architects Research Corporation are cooperating in a pilot project to define the influence of climate on design criteria for residential housing. The goal is to provide specific guidance to engineers and architects so that homes can be designed to be responsive to the climate and thus reduce fuel consumption.

The EDIS Environmental Science Information Center disseminates meteorological scientific and technical literature and information. In addition, it provides computer searches of reference files such as Meteorological and Geoastrophysical Abstracts (MGA). MGA is an EDIS-supported publication of the American Meteorological Society and is an index to the most important meteorological research reported in foreign and English literature.

A comprehensive national collection of meteorological publications is held in the central NOAA Library and Information Services system. It encompasses material inherited from the former Atmospheric Sciences Library, previously the U.S. Weather Bureau Library.

The EDIS Center for Environmental Assessment Services (CEAS) provides assistance to managers of critical national resources by assessing the impacts of climatic variations on food and energy resources and of offshore energy developments on marine environments and resources.

CEAS prepares data-based studies and weekly assessments of potential effects of climatic fluctuations on national and global grain yields. These reports are used by the Departments of Agriculture, State and other Federal agencies, as well as by foreign governments and international organizations, to minimize the effects of grain production failures in any region of the world. In addition, NOAA/EDIS, the National Aeronautics and Space Administration, the Department of Agriculture, Department of State and Department of Interior cooperate in the Agriculture and Resources Inventory Surveys through the Aerospace Remote Sensing (AGRISTARS) program that uses satellite crop monitoring, meteorological observations and EDIS data-based computer models to make estimates of future crop production.

During the heating season, CEAS issued projections of residential and commercial natural gas demand for multi-State regions of the conterminous United States on a monthly and seasonal basis. The projections are based on an EDIS index of cold weather and on National Weather Service seasonal and monthly outlooks. They are provided to the U.S. Department of Energy and others responsible for energy use and planning. A similar service is provided for the summer cooling season.

Climatic anomalies, such as the two recent severe winters in the eastern United States, have heavy impacts on agriculture, energy consumption and the national economy. To realize the enormous potential benefits of predicting such anomalies, it is necessary to develop the capability to model and predict the general circulation of both atmosphere and oceans, as well as the exchange of energy, momentum, moisture, carbon dioxide and other substances between them. A series of multination major field experiments has been sponsored by international scientific bodies to collect the interdisciplinary environmental data needed for this effort. Under broad names, such as the Global Atmospheric Research Program (GARP), these programs have used sophisticated sensors mounted on extensive arrays of moored and drifting buoys, ships, airplanes, balloons and satellites, sampling at high rates under careful control. CEAS has played a key role in GARP experiments, providing experiment design, data analysis and data management support to project managers and producing merged, validated multidisciplinary data sets for international and national dissemination and study.

EDIS is supporting state-funded state climatologists. As of October 1979, there were working agreements with 42 states and negotiations are underway with the remaining states. The activity is designed to expand NOAA's climatic data/information service capability to users at the local level; it provides a base from which to implement the intergovernmental climate program mandated by PL 95-367, Sec. 6.

The EDIS Reference Climatological Station Program involves a network of 21 climatological stations serving as anchor points to stabilize the national network of principal and ordinary climatological stations. The principal and ordinary climatological stations suffer from changes in location, environment (natural and artifical) and exposure. Thus, continuity is interrupted and climatic changes can be estimated only by statistical techniques. These anchor stations provide a "baseline" of climatological records, based on many years of observations in an undisturbed environment. EDIS furnishes technical leadership, monitors and funds the program. The National Weather Service operates the stations and furnishes inspection and maintenance service.

Under Code 10 USC 7393 and an Executive Order of July 29, 1904, EDIS furnishes meteorological data and analyses to be included in the Defense Mapping Agency Hydrographic Center's Pilot Charts and Sailing Directions Planning Guides. In addition, EDIS' National Oceanographic Data Center publishes the Mariners Weather Log, which contains articles on meteorology and is the official record of weather and tropical cyclones over the world's oceans.

NATIONAL ENVIRONMENTAL SATELLITE SERVICE (NESS)

Public Law 87-332 of September 30, 1961, provided the first appropriation for a National Operational Meteorological Satellite System. This basic meteorological service observing program consists of polar-orbiting and geostationary satellites. The U.S. Department of Commerce, through NESS, is the agency responsible for a national operational environmental satellite system. The Department is charged with operating and improving the system to meet the common requirements of all Federal agencies. The objectives of the operational system are:

- Provide global imagery of the Earth and its environment on a regular basis, day and night, including direct readout to local ground stations within radio range of the satellite.

- Obtain quantitative environmental data on a global basis, such as temperature, moisture, winds, radiation flux, and solar energetic particle flux, for use in numerical analysis and prediction programs.

- Obtain near-continuous observations of the Earth and its environment, collect data from remote observing platforms (including automatic weather stations, balloons, aircraft, ships, buoys and river and tidal stations) and broadcast weather data to remote locations.

- Improve monitoring and prediction of the atmospheric, oceanic, and space environments by developing applications of satellite information.

The operational satellite programs are directed toward satisfying the above objectives. The system also includes command and data acquisition stations; a satellite operations control center through which the satellites are controlled and data acquired; facilities for processing and analyzing satellite data and preparing products for distribution to the users; laboratories for developing new and improving existing applications of satellite data and conducting satellite instrument experiments; and programs for determining requirements of future operational satellite systems.

Satellite Field Services Stations (SFSS) have been established to analyze, interpret and distribute processed geostationary satellite products to regional National Weather Service offices and

other Federal agencies. The products are also made available to private activities at their expense. SFSSs are located in Washington, DC; Miami, FL; Kansas City, MO; Honolulu, HI; San Francisco, CA; and Anchorage, AL. The Anchorage SFSS distributes data from both the polar-orbiting and geostationary systems. The San Francisco SFSS also has the capability of receiving data from the polar orbiting satellites.

The TIROS N system of environmental polar-orbiting satellites is the replacement for the second-generation ITOS system. TIROS N, the NASA prototype, was launched by an Atlas launch vehicle on October 13, 1978. NOAA 6, the first NOAA-funded operational satellite of this series, was launched on June 27, 1979. NOAA-funded satellites retain the NOAA name and are numbered consecutively beginning with the number immediately following that last used in the ITOS series. Thus, NOAA "A" became NOAA 6 after it successfully achieved orbit. The third-generation TIROS N series system became fully operational on June 26, 1979, when NOAA 5, the last of the ITOS system, was deactivated. These satellites will focus on increasing the accuracy of weather forecasting by providing quantitative data required for improved numerical models. They will carry advanced instruments to provide improved temperature soundings and microwave channels to facilitate sounding retrieval in cloudy areas. They also will provide advanced multichannel images and will carry a new data collection and platform location system. During the lifetime of the TIROS N system, new instruments may be added or substituted for others. Therefore, the spacecraft are designed for a 25 percent growth capability in terms of weight, volume, power, command and telemetry.

These spacecraft are five-sided boxlike structures that are 3.71 m, long, 1.88 m in diameter and weigh 1,409 kg including expendables. This third-generation system consists of two satellites in orbit; therefore, there is no instrumental redundancy on either spacecraft. TIROS N was launched into a near-polar, Sun-synchronous 870-km orbit crossing the Equator in a northward direction at 1530 local time. NOAA 6 is orbiting at 830 km crossing the Equator in a southward direction at 0730 local time. This compares with an average orbital altitude of 1,500 km for the ITOS satellites. TIROS N is flown at a somewhat higher altitude to avoid extended periods of readout conflict. The orbital period of the satellites will be 101.58 minutes, which will produce 14.2 orbits per day. Determination of orbital parameters will become more significant at these altitudes. Additionally, maximum solar activity in 1980 will introduce significant perturbations to the orbit.

The TIROS N system satellites carry four primary instrument systems. The Advanced Very High Resolution Radiometer (AVHRR) will provide data for realtime transmission to both Automatic Picture

Transmission (APT) and High Resolution Picture Transmission (HRPT) users and for storage on the spacecraft tape recorders for later playback. Thus, the AVHRR instrument will continue and improve upon the ITOS satellite services in stored and direct readout of radiometric data for day and night cloud, sea-surface temperature and snow mapping. The data from the AVHRR instrument will be available from the satellite in four operational modes:

- Direct readout to ground stations of the APT class, worldwide, at 4-km resolution, of the visible and infrared data. Panoramic distortion will be removed.

- Direct readout to ground stations of the HRPT class, worldwide, at 1.1-km resolution, of all spectral channges.

- Global onboard recording of 4-km resolution data from all spectral channels. Global Area Coverage for commanded readout for processing in the NOAA central computer facility at Suitland, MD.

- Onboard recording of data from selected portions of each orbit at 1.1-km resolution of all spectral channels with Local Area Coverage for central processing.

The TIROS Operational Vertical Sounder (TOVS) system combines data from several complementary sounding instruments on the spacecraft. These instruments are the High Resolution Infrared Sounder (HIRS/2), the Stratospheric Sounding Unit (SSU) and the Microwave Sounding Unit (MSU). The primary instrument providing tropospheric data, HIRS/2, is sensitive to energy from the visible to the carbon dioxide region of the infrared spectrum. This instrument is designed to provide data that will permit calculation of temperature profiles from the surface to 10 mb, water vapor content at three levels of the atmosphere and total ozone content. The SSU instrument, which is sensitive to energy in the carbon dioxide portion of the infrared spectrum will provide temperature information from the stratosphere. This instrument is being provided by the Meteorological Office of the United Kingdom. The third instrument, the MSU, is sensitive to energy in the oxygen region of the microwave spectrum and will be used in conjunction with the two IR instruments. The microwave data will permit computations to be made in the presence of clouds.

The Data Collection System (DCS) is being provided by the Centre National d'Etudes Spatiales of France. The French call this the ARGOS Data Collection and Platform Location System. The ARGOS DCS provides a means to locate and collect data from fixed and moving platforms. It provides two new services not currently present in the geostationary satellite data collection system. First, it has the capability to determine platform location, using an inverse Doppler technique. Second, it is able to acquire data from any place in the world, but most particularly in the polar regions, beyond transmission range of the geostationary satellites.

The Space Environment Monitor (SEM) measures solar proton flux, alpha particle and electron flux density, energy spectrum and total particulate energy distribution, at spacecraft altitude. The three detectors included within this instrument are the Total Energy Detector, Medium Energy Proton and Electron Detector and High Energy Proton and Alpha Detector. This instrument will augment the measurements currently being made by NOAA's geostationary satellites. The data from the SEM will be processesd at Suitland, MD. and transmitted over a dedicated data link to NOAA's Space Environment Laboratory at Boulder, CO, within one hour of the spacecraft readout. The TIROS N system data along with the geostationary data will be used to monitor the state of solar activity, which has a significant effect on terrestrial communications, electrical power distribution and high-altitude flight in aircraft such as the Concorde SST.

Because of the large volumes of digital data generated by the TIROS N system satellites, a new ground system was required. The ground system consists of two major subsystems, the Data Acquisition and Control Subsystem (DACS) and the Data Processing and Services Subsystem (DPSS). The DACS includes components at the Wallops, VA, and Gilmore Creek, AL, Command, and Data Acquisition (CDA) stations, the Satellite Operations Control Center (SOCC) in Suitland, MD, the Western European Station in Lannion, France, and the Satellite Field Services Station in San Francisco, CA. All the DPSS components are in the NOAA facility at Suitland.

DACS includes all components necessary to command and control the spacecraft, monitor its health via housekeeping telemetry and retrieve and transmit the spacecraft environmental data to the DPSS processing and data handling facility. The delivery of TIROS N system data from the CDAs to Suitland is accomplished using the RCA American Communications, Inc., commercial satellite communications network. This system, which includes recently installed Earth Stations at Suitland and Wallops, will deliver the data to SOCC. The data are immediately passed on to the DPSS subsystem for initial processing. This new ground system was accepted in February 1979.

During three sequential orbits and occasionally four on some days, the spacecraft is out of range of both NOAA CDA stations. To eliminate the resultant time delay in the receipt of the high-priority sounding data during the "blind" period, a Western European readout station was established at Lannion, France. This station acquires stored sounding data and transmits it to the United States via the eastern GOES satellite located at 75W.

The DPSS ingests the raw satellite data, and preprocesses and stores them along with appended auxiliary information such as Earth location and quality control parameters. DPSS consists of several unique segments of high-speed computers, intermediate disk storage

units and a mass data storage system. Thus, all the data obtained from a single TIROS N system spacecraft for a 24-hour period can be stored on a single tape.

The geostationary satellite program began during the latter half of the 1960s as an operational experiment in which the imaging capability and broadcast system (WEFAX) of the NASA Applications Technology Satellites 1 and 3 were used. The program became an operational reality following the launch of NASA'S Synchronous Meteorological Satellites (SMS) 1 and 2 in 1974 and 1975, respectively. NASA released to NESS both SMS 1 and 2 for operational control and use following the initial checkout period. These satellites were the prototypes for NOAA's Geostationary Operational Environmental Satellites (GOES). GOES 1 was launched October 16, 1975, GOES 2 was launched June 16, 1977, and GOES 3 was launched June 16, 1978. SMS 2 is the eastern (75 W) operational satellite and GOES 3 is the western (135 W) operational satellite. GOES 1 was moved to 60 E over the Indian Ocean in December 1978 to support the Global Weather Experiment from December 1, 1978, to November 30, 1979. SMS 1 and GOES 2 remain in orbit in a standby mode. GOES 2 and GOES 3 provide repetitive viewing of the development and movement of destructive weather systems, such as thunderstorms, hurricanes and major midlatitude storms over much of North and South America and adjacent oceans. The principal instrument is the Visible and Infrared Spin Scan Radiometer (VISSR). The VISSR provides near-continuous cloud viewing with resolutions of 1, 2, 4 and 8 km in the visible wave lengths and 8 km in the infrared wavelength. Full Earth disc pictures are available at 30-minute intervals throughout the day and night; partial disc pictures can be obtained at more frequent intervals to meet special requirements such as viewing development and movement of severe storms. The GOES Data Collection System is used to collect and relay environmental data observed by remotely located sensing platforms, such as automatic weather stations, buoys and river and tide gages. These satellites also broadcast environmental data to remote locations using the WEFAX system, and collect data from warnings of solar activity using the Space Environment Monitor. Table 9 shows the launch schedule for polar orbiting and geostationary satellites by the Department of Commerce.

The National Oceanic Satellite System (NOSS) is proposed jointly by NOAA, NASA and the DOD. All three agencies will participate in the program. NESS is requesting resources in FY 1981 to support the NOAA share of start-up costs. Part of these resources are for procuring a second spacecraft and instruments. According to tri-agency agreement, NASA will fund the first spacecraft. Also under this agreement, NOAA will share the costs of implementing the ground data system and operational costs during the demonstration. The remainder of the FY1981 resources will go toward ground system support. The ground system includes the Primary Processing Facility, data dissemination by commercial communications satellites, and interface terminals to the user's

data processing facilities. NOAA must modify its data handling and processing system. NOSS data will be used to meet increasing demands from marine areas such as commercial fishing and shipping, off-shore drilling operations, military operations, and recreation.

Research Program for FY1981

Some of the ongoing research programs for FY1981 will emphasize the development of global, quantitative products such as sea surface temperature, sea ice coverage, Earth radiation balance and cloud cover for inputs to the climate program; development of techniques and instruments for global monitoring of trace gases in the stratosphere; and continued improvement of existing data inputs into the NWS forecast models.

POLAR-ORBITING SYSTEM

Satellite Designator	Planned Launch Date	Instruments TIROS N Series
NOAA B	3QFY80*	AVHRR - Advanced Very High Resolution Radiometer
NOAA C	FY 1981*	TOVS - TIROS Operational Vertical Sounder
NOAA D	FY 1982*	SEM - Space Environmental Monitor
NOAA E	FY 1983*	DCPLS - Data Collection and Platform Location System (ARGOS)
NOAA F	FY 1984*	HIRS/2- Modified Height Resolution Infrared Sounder
NOAA G	FY 1985*	
NOAA H	FY 1986*	
NOAA I	FY 1987*	

GEOSTATIONARY SYSTEM

Satellite Designator	Planned Launch Date	Instruments
GOES D	4QH 1980*	SEM - Space Environment Monitor
GOES E	FY 1981*	DCS - Data Collection System
GOES F	FY 1983*	VAS - VISSR Atmospheric Sounder (GOES D and subsequent spacecraft)
GOES G	FY 1985*	VISSR - Visible and Infrared Spin Scan Radiometer
GOES H	FY 1986*	

*Launch date depends on performance of prior spacecraft.

TABLE 9
PROJECTED LAUNCH SCHEDULE

Other NESS research efforts will be directed toward technique development to define efficient methods of extracting oceanographic information from satellite data. In another area, calibration procedures are being developed for the visible and infrared channels of the visible and infrared spin scan radiometer, and radiation budget parameters will be obtained from geostationary satellites for the climate program.

In addition, the operational utility of data obtained from SEASAT will continue to be assessesd. Although SEASAT ceased functioning after only 3-1/2 months, sufficient data were collected to evaluate its ability to provide information on surface wind stress, boundary layer winds and major ocean currents. These began in FY1979 and will be conducted at a reduced level of effort until concluded in FY1981.

Satellite Communications System

The NESS Telecommunications System (SATCOM) is divided into two discrete subsystems, one serving the NOAA polar-orbiting satellites (NOAA) and the second serving the geostationary satellites (GOES) and the associated Satellilte Field Services Stations (SFSS). The major elements in the polar-orbiting satellite subsystem are the CDA stations at Wallops, VA, and Gilmore Creek, AL, and the Satellite Operations Control Center in Suitland, MD. The Synchronous Satellite Subsystem connects the Wallops CDA station with the Central Data Distribution Facility (CDDF) at Camp Springs, MD.

The CDDF is connected in turn with the Gilmore Creek CDA station, with the six SFSSs located in Washington, DC; Miami; Kansas City; San Francicso; Anchorage; and Honolulu; and with the NWS San Juan, PR WSFO. The Gilmore Creek CDA station also relays satellite data by two satellite distribution circuits to the Anchorage SFSS and the NWS WSFOs at Anchorage, Fairbanks and Juneau.

To support the new TIROS-N series operational satellite system, new communication links were added in FY1979. By the end of FY1979, SATCOM consisted of the following high- and medium-speed links:

- Five 12-megahertz full-duplex terrestrial microwave circuits between the World Weather Building and the Federal Office Building #4 at Suitland, MD for relay of GOES data.

- Two full-duplex alternate C4 2400-hertz data/voice satellite and terrestrial circuits connecting Suitland with the Anchorage SFSS and Gilmore Creek CDS station for relay of GOES data and voice coordintion.

- 2,400-hertz full-duplex circuits from computer output at the CDDF to display units at the SFSSs, the Gilmore Creek CDA station and the San Juan WSFO.

- 2,400-hertz circuits from the Suitland computer to the Wallops CDA station to transmit WEFAX information.

- 2,400-hertz circuits from the Wallops CDA station to the Suitland computer for relay of GOES Data Collection System (DCS) information.

- 300-, 1,200-, and 4,800- and 9,600-hertz circuits for delivery of DCS information from the World Weather Building computer to a multitude of users. Computer-to-computer transmission is used in most cases.

- 7,200-hertz full duplex computer-to-computer circuits for exchange of vertical profile radiometer data between Goddard Space Flight Center and Suitland.

- One 50-line and one 40-line multipoint voice coordination and conferencing network connecting NESS operating facilities.

- One 15-line multipoint voice coordination and monitoring network at Suitland for Control and integration of launch activities.

- Two 100 wpm multipoint teletypewriter circuits connecting various elements of SATCOM.

- A direct alternate voice, data, or facsimile circuit between Washington and Moscow for exchange of satellite information.

- Two 1.3308 megahertz simplex satellite circuits for relay of TIROS N data from the two CDA stations to Suitland, MD and the RCA Ground receiving station at Offutt Air Force Base, NE.

- Four alternate 9,600 hertz data/teletype and voice full duplex satellite and terrestrial circuits between the two CDA stations and Suitland, MD to relay real-time TIROS N data, to transmit command and control functions to the TIROS N spacecraft, and to provide alternate routing and backup for TIROS N teletype and voice communications.

- Two full-duplex combination teletype and voice satellilte and terrestrial circuits between the two CDA stations and Suitland, MD for coordination of TIROS N operations.

- One simplex C-5 conditioned data facsimile circuit between the Wallops CDA station and Suitland, MD for the relay of sectorized TIROS N HRPT data.

ENVIRONMENTAL RESEARCH LABORATORIES (ERL)

ERL R&D programs related to basic meteorological services are oriented toward providing the understanding and developing the techniques and new technologies that will form the basis for future improvements in the nation's weather services. The responsibility for work on this important function encompasses the mission of several ERL laboratories.

Severe weather is any major natural hazard such as flash flood, strong winds, thunderstorms (including tornadoes and hail), heavy snowstorms and clear-air turbulence affecting aviation. From the health standpoint, air pollution can be considered a hazard although it results from human activities. The above phenomena are all associated with small- to medium- scale disturbances in the atmosphere.

The new Prototype Regional Observing and Forecasting Services (PROFS) program has begun its four-year phase in the Boulder/Denver, CO, area. The PROFS mission is to create an improved local weather service capability that is cost effective and directly responsive to society's present and future service requirements. The main objectives of Phase I of PROFS are to design an overall prototype local weather service system using the identified requirements for local services and current technology and to create an Exploratory Development Facility (EDF) to test and integrate into the PROFS system various candidate technological solutions.

The National Severe Storms Laboratory (NSSL) in Oklahoma concentrates on severe local storms, especially those phenomena associated with intense thunderstorms. Since 1971, NSSL has used and refined Doppler radar, probing the interior windfields of severe thunderstorms. The early promise of Doppler radar for greatly improved detection and warning of tornadoes led to a cooperative interagency project (Joint Doppler Operational Project with NOAA, DOD, and FAA) to test the operational usefulness of Doppler radar for the Nation's weather services. Results from this Joint Doppler Project have been very encouraging during the 1977-79 storm seasons (including SESAME '79 Project) and will be used in the design of replacements for the existing NWS radars in the 1980s. Some of the JDOP personnel from ERL and other agencies will be assigned to the new NEXRAD JSPO to assist in planning the NEXRAD program. Other new remote sensing techniques, some of which can be automated, have been developed by the Wave Propagation Laboratory to assist in the measurement and warning of severe local storm phenomena.

The SESAME 1979 Field Project was executed through a cooperative pooling of existing resources and proved to be a landmark in acquisition of data for regional-scale numerical model development and a variety of storm-scale objectives. Major data

collection from a variety of sensors in the central United States occurred on 13 days during the period 10 April to 11 June, while more limited operations were carried out during an additional 21 days. Phenomena observed in detail included evolution of the pre-convective boundary layer, short wavelength upper atmospheric disturbances, low-level jets, cumulus through cumulonimbus stages of convection (some with tornadoes) and several intense rainfall events.

The success of SESAME '79 is due in large part to the cooperation of 16 universities, 14 Departments or Agencies of the Federal Government including four military services, National Guard units from three States, Research Councils of the United States and Canada, a private contractor, and the National Severe Storms Laboratory in Oklahoma. Data analysis and model testing will be supported by NOAA, NSF and NASA into FY1981 and beyond.

Scientists at the Atmospheric Physics and Chemistry Laboratory (APCL) in Colorado have been performing detailed analyses of recent flash flood episodes and developed regional climatologies to discover common features useful for forecasting. They have also pioneered in the development of mesoscale numerical models capable of simulating terrain-induced rain and snowstorms and the growth scale of heavy thunderstorms. APCL scientists are participating with NWS, in a four-State Appalachian flash-flood test program started in FY1980. They plan to continue diagnostic mesoscale analyses of major flash flood episodes and to continue development of mesoscale numerical models capable of predicting flash floods.

During FY1981, ERL will initiate a new 10 year Cumulus Dynamics and Microphysics Program (CDMP). The scientific goal of the CDMP is to provide the basic understanding of the physical processes that underlie weather modification programs to increase precipitation from cumulus cloud systems. This increase will enable NOAA to: (1) establish a physical basis for the concept of dynamic seeding, (2) increase the understanding of the mechanisms of convective cloud organization and growth, and of precipitation processes and (3) provide a valid scientific basis for the design of experiments to test and evaluate weather modification technologies. Investigations will be conducted of the physical linkages involved in the dynamic seeding of convective clouds through comprehensive field observing programs, data analyses and numerical modeling studies. The first field program is scheduled to occur over a four- to- six week period during the summer of FY1981 in a site to be determined from preselected scientific criteria, for example, South Florida, the Upper Plains, Illinois, etc. During FY1981, a detailed design of this field experiment will be carried out using modeling simulations and field testing of conventional in-situ and new remote sensing techniques for probing convective clouds and precipitation, as well as using experimental design studies from the previously acquired Florida Area Cumulus Experiment (FACE) data.

A new radiometer device that shows great promise for warning airline pilots of clear-air turbulence (CAT) in flight has been developed and tested by APCL scientists on NASA research aircraft during 1977-79. During FY1980 operational tests of the radiometer are being made on commercial airliners and NASA aircraft. Another radiometer to warn pilots of hazardous low-altitude wind shear as they are making final landing approaches to airports was tested during SESAME 1979. During FY1981, a final report on the operational performance of the CAT radiometer will be published.

A new airborne Doppler radar system has been developed and tested by ERL scientists on one of the new NOAA P-3 aircraft. The airborne Doppler system has potential for measuring detailed vertical velocities., i.e., updrafts and downdrafts, in convective storms overflown by the aircraft. Additional flight tests were planned during FY1980 through Florida convective clouds. After these data are analyzed, specifications for a research prototype airborne Doppler system will be established during FY1981.

Data from the NOAA P-3 aircraft flights into the destructive 1979 Hurricane David and Frederic are being analyzed by scientists at the National Hurricane and Experimental Meteorology Laboratory (NHEML) in Florida, to provide new details and insights on hurricane motion and intensification, both difficult to forecast at present with sparse data over the oceans. The new joint initiative with the National Hurricane Center, called Hurricane Strike, was initiated and aims at using the P-3 aircraft and numerical modeling capabilities at NHEML to improve forecasts of short-term intensity and track changes and location of hurricane landfall. In addition, NOAA obtained additional flight hours for its Research Facilities Center in FY1980 for increased flight support to improve hurricane modeling (especially for Hurricane Strike) and several other ongoing programs.

APPENDIX C

DEPARTMENT OF DEFENSE

UNITED STATES ARMY

The primary mission of the Army, related to meteorology, is to maximize worldwide combat and strategic effectiveness by continually improving Army-required atmospheric related products. The Army role is defined in AR 115-10/AFR 105-3, 18 May 1970.

Today, Army research emphasis is being placed on atmospheric transmission problems associated with electro-optics and near-millimeter wave lengths; on high energy laser weapons; on artillery and rocket ballistic problems; and on making up-to-the-minute atmospheric information on the mesoscale available. Such information can give the field commander an integrated weather picture.

Atmospheric Models for Electro-Optical and Near Millimeter Wave Systems

The principal objective of the Army's electro-optical (E-O) and near millimeter wave (NMMW) modeling program is to have a means by which atmospheric effects on E-O and NMMW systems can be determined for weapons developers, systems analysts, war gamers, tacticians and modeling testers without resorting to expensive, time consuming testing of these systems under simulated, low visibility battlefield conditions. This program includes measuring and modeling the atmospheric propagation of electromagnetic energy for battlefield conditions (e.g., smoke, fires, explosion debris, fog clouds, snow, vehicular dust); development of models to describe natural and artifical dust, smoke and chemicals and their battlefield propagation characteristics; and development of transport and diffusion models for the battlefield, relating propagation conditions to meteorology. These efforts culminate in the development of the Electro-Optical Sensor Atmospheric Effects Library, known as E-O SAEL, for various battlefield regions based upon climatic considerations. Currently, the work focuses on the development of obscuration models for potential battlefield zones in Europe. These models feed into one-on-one and force-on-force combat models, as well as into system performance and smoke obscuration models.

Atmospheric Characterization.

This program addresses the characterization of the optical properties of the atmosphere and the determination of the relationship of these properties to meteorological conditions. The objective is to provide the atmospheric information needed by military developers of E-O, NMMW and high energy laser (HEL)

systems for evaluating system performance and determining system designs. Atmospheric influences are assessed by quantitative characterization of potential battlefield environments at all wavelengths from the visible to millimeter. This task will be accomplished by a field measurement program which includes optical turbulence, crosswind, extinction coefficients for gasses and particulates, lidar transmission and backscatter measurements, particle size (clouds, fog, smoke, dust) and concentration measurements, analysis of wet and dry aerosols and infrared (IR) and NMMW transmission measurements. The measurements will be analyzed and reported in a suitable format for direct input to systems designers and for validating atmospheric models in E-O SAEL for specific battlefield zones. Various field tests will be conducted to develop and to validate computer models describing obscurations produced by dust, debris and smoke with special attention given to the vertical distribution of obscurants and to slant path transmission.

The U.S. Army Atmospheric Sciences Laboratory (ASL) has been designated lead laboratory for meteorological support to the DOD National High Energy Laser Test Range (NHELTR) at White Sands Missile Range, NM, and has the responsibility for developing and implementing a technology, measurement and meteorological support program for the NHELTR.

This support crosses the technical base and meteorological operational support lines. The technical base program addresses (a) development specialized site-peculiar measurement techniques and equipment, (b) establishment of optical turbulence, crosswind, gasses, particulates and site-peculiar micro-meteorological data bases, and (c) specialized data reduction and analysis techniques and development of operational techniques. The operational meteorology program (a) identifies operational support from scenarios provided by each service, (b) tailors support to the mission and procures off-the-shelf instrumentation in sufficient time for the mission and identified non-standard instrumentation requirements for implementation, and (3) provides operational support and takes over technical use support as techniques and equipment are developed.

An example of atmospheric characterization during a system test is the support provided during the Air Force field tests of the Maverick System in Baumholder, Germany, in February 1978, in which IR transmission and meteorological conditions were monitored by two Army laboratories - Night Vision and Electro-Optics Laboratory (NVEOL) and ASL. Similarly, during the Copperhead Ground Fog Experiment at Fort Ord, CA, in April-May 1978, ASL provided 24-hour meteorological watch, obtained vertical aerosol profiles, monitored the size distribution and concentration of fog particles, and measured visibility. These measurements are being used to relate the fog conditions at Fort Ord with the fog conditions in West Germany.

In responding to the need for more information about the optical properties of the battlefield atmosphere, ASL conducted the Dusty IR Test (DIRT 1) at White Sands Missile Range (WSMR) during October 1978. One of the test objectives was to examine dust clouds generated by explosions and provide specific optical data for low-visibility battlefield conditions required for the E-O SAEL development. A second objective provided a preliminary test of a sophisticated technique for sampling explosion debris clouds to directly measure their optical and physical properties.

Meteorological Equipment

One of the major meteorological equipment development projects is the Automatic Atmospheric Sounding Set AN/TMQ-31 (formerly the Field Artillery Meteorological Acquisition System), designed to replace the aging AN/GMD-1 rawinsonde system for the measurement of upper air wind speed and direction, temperature, humidity and pressure. The AN/TMQ-31 is the newest type equipment that provides accuracies, capabilities, flexibility and features not available in other atmospheric sounding systems. It is being designed in support of Army artillery fire, but also provides data for other Army users. The purpose of the AN/TMQ-31 is to give the artillery sections the improved capability of first round hits, even in areas obscured from observers, by providing reliable, fresh (hourly) and comprehensive meteorological data. These data are obtained through the available passive techniques of NAVAID or RDF radiosonde tracking systems. The AN/TMQ-31 combines both techniques into a small system in which the fully automatic ground receiving, computing, display and transmitting equipment are housed in an S-280 shelter (2-1/2 ton) and the RDF antenna/pedestal is on a 1-1/2 ton trailer.

With the AN/TMQ-31 still under development, the Meteorological Data Processing Group OL-192 was fielded in 1979 to test an improvement to the GMD-1 that incorporates a sophisticated calculator solution to replace manual computations. The calculator, somewhat like a minicomputer, speeds up plotting procedures used to convert raw meteorological data into ballistic meteorological messages. The calculator will permit reduced personnel, increased firing accuracy and more frequent observations. Tests by OL-192 operated satisfactorily with no deficiencies in all testing and the calculator was distributed to active Army and National Guard units in mid-1979.

ATMOSPHERIC SENSING

The main purpose of Army research involved in the sensing and probing of the atmosphere is to determine the atmospheric effects on the performance of battlefield devices. This includes existing, prototype and future weapon guidance systems, remote atmospheric sensing systems and high energy laser (HEL) systems.

New atmospheric sensing techniques can increase the combat effectiveness of weapons and operations. The recent developments in remote sensing technology are being exploited to measure atmospheric parameters which reduce weapon system effectiveness. For the first time, measurements can be used for direct fire weapons such as on the main battle tank and on the AH-1 and AAH aircraft.

Research has been initiated to extend the range of remote wind sensors. The most promising techniques include microwave Doppler, pulsed Doppler, modulated laser doppler and differential Doppler. A description of two of these systems follows:

(1) Helicopter Remote Wind Sensor (HRWS). The operational concept of the Helicopter Remote Wind Sensor is to augment a fire control system for either AH-1 or AAH aircraft. Due to the nature of the free-flight armaments, wind information along the intended trajectory is needed to ensure effectiveness at extended ranges from hover. The HRWS will measure wind speed and direction in the aircraft turbulent environment and average winds along the intended trajectory for several hundred meters. Growth potential is large and could readily include true air speed, a low altitutde altimeter and a rangefinder.

(2) Prototype Crosswind Sensor for Army Applications (tank). The state of the atmosphere has an effect on Army operations and weapons systems employment. In order to increase relative combat power, measurement of the meteorological parameters must be made at the time of action and at the location of that action. It is now feasible to develop real-time integrated path crosswind sensors for tanks to collect and analyze these type data to correct for crosswinds effects during main gun employment.

Army personnel, who will use future weapon systems such as the COPPERHEAD Artillery Projectile, have no means for objectively measuring ceiling and visibility. During 1980 a prototype ceiling-visibility sensor, the visioceilometer, will be feasibility tested and demonstrated to the user. This hand-held sensor is designed to provide high-resolution ceiling and visibility information in a real-time mode and was based on a ground meteorological direction finder, the AN/GVS-5 laser rangefinder.

Meteorological Techniques for Artillery.

This portion of the Army RDT&E effort addresses Artillery in three principal areas: 1) atmospheric effects on ballistics with emphasis on long range, high altitude projectiles; 2) atmospheric effects on target acquisition, and (3) atmospheric effects on the behavior of munitions at target, including screening, obscuration and chemicals/munitions.

Within the first area of effort - ballistics - the current thrust is to improve first round hit probability by more accurately assessing the meteorological contribution to the total artillery error budget and to refine methodology by which meteorological data are acquired and applied to artillery ballistic corrections. Specific milestones being addressed are:

a. Determine meteorological error budget for the Field Artillery Meteorological Acquisition System (FAMAS).

b. Redefine the method by which the structure of the atmosphere is depicted for ballistic applications.

c. Extend the altitude through which the atmospheric data are tailored for artillery applications (from 20 km to altitudes in excess of 30 km).

d. Establish reliability factors for meteorological time and space variability effects on weapons systems.

In the second area, target acquisition, the current thrust is the increased effectiveness of sound ranging. The largest portion of the sound ranging error budget is meteorological in origin. Techniques are being developed to reduce target location errors by determining more precise meteorological corrections for use in target location, and by applying advanced mathematical techniques and efficient computer capabilities to these solutions. A recent result of this effort has been the completion of the target acquisition program that was issued to Artillery meteorological units and planned for issuance to Target Acquisition units. (See page 76.)

The third thrust, munitions at target, is being addressed by assessing the effects of atmospheric behavior on the dispersion of multi-munitioned projectiles and of the transport and diffusion of smokes, gasses and chemical/radiative agents. This effort progresses through the following specific areas:

a. The KWIK munition-expenditure model is being developed to account for atmospheric transport, diffusion, humidity, visibility and terrain effects on the effectiveness of smoke munitions. Theoretical results of this model indicate significantly reduced munitions may be required if these atmospheric parameters are more fully accounted for. Evaluative field tests were planned for FY1980.

b. The meteorological time and space variability studies are also being used to assess the effect on the dispersion of bomblets over the target area.

Tactical Weather Intelligence

This effort provides techniques and/or models for near real-time depiction of mesoscale (battlefield) meteorological conditions for both direct (through such Intelligence systems as the All Source Analysis System) and indirect support of modern tactical Army intelligence functions and weapons systems. Typical systems are electro-optical (E-O) and precision guided munition systems where their utility is influenced by natural (clouds, fog, precipitation, etc.) and manmade (smoke, dust, etc.) obstructions to propagation which derive their character from atmospheric conditions. Automation is utilized to reduce manpower and enhance quality and timeliness. Battlefield effluent models will be combined with transport and diffusion models to define, with specific scenarios, techniques for estimating the atmospheric environment for E-O system employment and deployment decisions in a tactical environment. The battlefield environment as affected by the distribution and concentration of dust, smoke, etc., must be described in a manner such that Army commanders will have appropriate and adequate weather intelligence for tactical decision making. In addition, meteorological models of atmospheric moisture (clouds, precipitation, fog, haze) will be developed to analyze their effects on E-O device utilization. The models being developed for tactical intelligence functions also have application to Force-on-Force War Games and weapon system developments.

Meteorological Support Activities

Meteorological support to Army RDT&E activities is provided through the combined efforts of both civilian and Army meteorologists, observers and technicians. The mission of providing timely and accurate atmospheric data is accomplished by the deployment of 12 permanent meteorological teams, 10 located in the contiguous States and one each in Alaska and the Republic of Panama.

The measurements provided to the various users encompass the entire spectrum of atmospheric scales; i.e., micrometeorological measurements of mechanical and thermal turbulence in the surface boundary layer to macroscale measurements of winds and thermodynamic parameters in the troposphere and stratosphere. Types of measurements include the more familiar ones of temperature, relative humidity, pressure, solar radiation and winds to more sophisticated measurements of optical turbulence, and E-O measurements relating to "seeability," and remote measurements of winds along an integrated path.

A partial list of Department of Army projects being supported includes SM-1 TANK, Advanced Attack Helicopter, Global Positioning System, HEL and many major tests of various projectiles, fuzes and tubes. Other support includes environmental/exposure tests of system electronic components, clothing, personal equipment, weaponry and various types of construction materials. The Army is currently undertaking a major program of modernizing the equipment used for data collection in order to support these advanced systems.

Army operations have always been affected by the atmosphere in which they must be accomplished, but never so extensively or critically as today's operations using modern weapon systems. With emphasis on more sophisticated sensors, fire-control systems and weather intelligence requirements, the annual research investment by the Army is of increasing importance and will provide the necessary products to cope with fluid battlefields on a worldwide basis.

The Army has 29 authorized artillery ballistic meteorological sections located throughout the world. Their primary function is to provide accurate environmental data for correction of artillery firing. In addition, data are provided to other elements of the Army for sound ranging and Chemical/Nuclear Defense operations, fallout forecasts, and AWS units for synoptic purposes.

Army and Air Force meteorologists are assigned to the US Army Training and Doctrine Command (TRADOC) to assist in the mission of determining how the Army should fight, how it should be equipped and formulation of pertinent doctrine. Documents, such as the Catalog of Approved Requirements Documents, provide guidance for the development of new meteorological equipment and techniques.

Other Army meteorological support personnel are assigned to Army research, development, test and evaluation activities. The US Army Material Development and Readiness Command conducts atmospheric research and development primarily at the Atmospheric Sciences Laboratory. The US Army Material Development and Readiness Command Atmospheric Sciences Laboratory provides meteorological RDT&E teams.

Meteorological training within the Army is the responsibility of the US Army Training and Doctrine Command. Training of warrant officer and enlisted meteorological personnel is conducted at the US Army Field Artillery School, Fort Sill, OK and Chanute AFB, IL. Officer personnel are trained at civilian universities.

Air Weather Service units provide direct weather services to the US Army tactical units in accordance with Joint Regulations.

UNITED STATES NAVY

The Navy's meteorological organization, as described in the previous plan, has recently undergone significant change. The Naval Oceanography Command, reporting directly to the Chief of Naval Operations and headquartered in Bay St. Louis, MI was established on 1 October 1978. The functions previously performed by the Director, Naval Oceanography and Meteorology, and some functions of the Oceanographer of the Navy have now been assumed by the new command. The purpose of this reorganization was to

consolidate the management of the Navy's oceanographic program, which includes the disciplines of meteorology, oceanography, and hydrography (mapping, charting and geodesy) to achieve a more effective and responsive service to the fleet.

The Navy Research and Development efforts include the following environmental support oriented programs for improvement of the direct support of fleet requirements.

Remote Ocean-Surface Measuring System (ROMS).

The ROMS effort will develop and demonstrate a capability to measure and process ocean surface parameters from an operational satellite and ground processing system to achieve the requirements for Satellite Measurement of Oceanograaphic Parameters. The Project will provide technology options to either integrate oceanographic sensors into existing and planned Defense Meteorological Satellite Programs (DMSP) satellites in the mid-1980's and utilize the Navy's Satellite Processing Center (SPC) at Fleet Numerical Oceanography Central (FNOC), or participate in an interagency development of a National Oceanic Satellite System (NOSS).

Automated Environmental Prediction System (AEPS).

The AEPS program will develop an automated system to achieve a 1985 capability to provide essential environmental support requirements to Navy Command and Control. The system will expeditiously process and analyze meteorological/oceanographic data needed to describe air/ocean interactions in order to define environmental features affecting the naval operating areas around the globe; to predict atmospheric and oceanographic conditions that affect naval operations with the timeliness, accuracy, and scale of predictions necessary to meet command and control and weapons/sensor system requirements; and formulate, disseminate and display weapons/sensor systems performance predictions based on predicted environmental conditions. Emphasis is on analysis and prediction improvements. Testing of systems within this project will be accomplished independently and integrally.

Some of the features of the AEPS will be:

- Model Output Statistics (MOS) of winds, cloud cover, ceiling and visibility; steering and wind distribution statistics in the FNOC tropical cyclone program; split-explicit tropical cyclone model; modified global prediction system for the FNOC upgraded computer; a 3-D mesoscale model; Genesis Potential (GP) capability on FNOC system; tropical cyclone strike probability; development of meteorological shipboard aids for use on interim tactical environmental support systems; Artic Ice Joint Experiment (AIDJEX), and Hibler dynamic sea ice models for FNOC system; and an Optimum Path Aircraft Routing System (OPARS).

Automated Environmental Prediction System II (AEPS II).

This project will develop an automated system to provide environmental prediction to Navy Command and Control. It will provide upgraded software divided into six subsystems with major effort in Systems Control and Monitor (SCM), Preparation, Transmission and Display (PTD), and Integrated Data Base (IDB)--minor effort in upgrading Report Processing, Analysis and Prediction. Relevant advanced development technologies of AEPS will be integrated into operational systems.

Tactical Environmental Support System (TESS).

TESS will be a modular Tactical Environmental Support System to: (1) predict/assess the performance of weapon systems as influenced by natural environmental conditions, (2) provide on-scene environmental data for use in the exercise of command and control, and (3) display information on automated interactive graphic and alphanumeric terminals. This project consolidates Environmental/Weapons Effectiveness Prediction System (E/WEPS), applicable portions of Naval Environmental Display Stations (NEDS) and Integrated Command Acoustics Prediction System (ICAPS) into a single project named TESS.

Meteorological Measuring System (MMS).

This system will correct an operational deficiency and develop an environmental measurement and display capability, in support of Command and Control. MMS capability will enable: (1) measurement of on-scene environmental parameters needed to (a) assess/predict the effect of the environment on weapon systems performance, developed in TESS and (B) support airborne ASW, AEW and ESM missions; (2) processing, communication, storage and display of environmental data, derived products and weapon systems performance parameters generated by AEPS, MMS includes: (1) E-2 Aircraft Microwave Refractometer (AMR), (2) P-3/S-3 Aircraft Dropsonde, (3) shipborne Mini-Refractionsonde (Minisonde), (4) Shipborne/airborne remote sensors, and (5) family of Naval Environmental Display Stations (NEDS).

Satellite Data Processing Center (SPC).

This project will fulfill a requirement to receive and process data from Defense and National satellite systems to alleviate global maritime data scarcity. An initial operational capability was achieved in FY1980. During FY1981, emphasis will be to implement application models to use derived sea surface temperature, ice prediction models and to refine the temperature profile calculations from satellite data. Also, wind data from remote ocean areas, obtained from satellite images will be used in the upper air analysis program. The Navy will continue systems software development for updated sensors and, development of display and dissemination procedures for fleet users.

Remote Sensing Instrumentation Program.

Remote sensing employed on ship, air and space platforms will enable cost effective measurement of environmental parameters over large volume and essentially in real time, revealing structure and dynamics in ways not possible with in-situ observations. Various remote sensing techniques will be investigated, including multispectral (UV, visible, IR), passive/active microwave, and lidar sensors, for measuring atmospheric, oceanographic surface/subsurface and terrain/soil parameters. Experimental remote sensors will be built and field tested to validate sensor algorithms for converting sensor output to geophysical parameters, ie., sea surface winds and waves, surface/subsurface temperature, ice, bathymetry, trafficability and atmospheric moisture.

Environmental Instrumentation

Accurate and timely environmental measurements are needed as input to separately developed weapon system performance assessment and prediction models, to facilitate on-site tactical decisions of deployed fleet units. Therefore, the objective is to develop meteorological equipment, compatible with existing and future airborne and sea based platforms for making in-situ measurement of atmospheric parameters. Ultimately, meteorological sensor electronics will be integrated with aircraft avionics and sensor output will be processed in onboard multi-sensor processors.

Atmospheric Environmental Support.

New and better techniques will be developed for analysis and prediction of atmospheric parameters to improve forecasting skills for longer periods of time in support of naval operations. Emphasis is on improvement of numerical dynamic and objective forecast techniques. Techniques will be developed for using data from advanced satellite sensors to better define the 3-D atmospheric structure for the initialization of dynamic forecast models, and to better define operationally important environmental parameters.

The Navy's Oceanography Program provides meteorological, oceanographic, mapping, charting and geodesy and precision time service in support of operational fleet forces.

Due to the close and dependent relationship of the atmosphere and the oceans, it is difficult to separate and distinguish the efforts that go into the preparation of separate meteorological and oceanographic products and services provided to meet fleet requirements. Consequently, functions of various activities cannot be separated into meteorology and oceanography but will be referred to as "air-ocean environmental". Most of the activities (all except those having only hydrography functions) have significant air-ocean environmental functions and provide a world-wide air-ocean environmental forecasting and warning service to the operating forces. The services performed by these activities are briefly described in the following six paragraphs.

FLENUMOCEANCEN - The Fleet Numerical Oceanography Center (FNOC).

Monterey, CA is the computer center of the Naval Oceanography Command. It is the hub of the Navy Environmental Data Network (a high speed two-way communications network designed and used for product distribution to COMNAVOCEANCOM activities). It is linked with the data collecting networks of the Air Force Automated Weather Network (AWN) and the National Oceanic and Atmospheric Administration (NOAA), and receives world coverage of original data. From these data, basic and applied numerical (computer) air-ocean environmental products are generated for the support of other Naval Oceanography Command activities. These activities, in turn use the original products to derive specific fleet support products and services. Some unique air-ocean environmental parameters, including ocean acoustic data and weapons and sensor performance indices, are provided directly to the operating forces by the FLENUMOCEANCEN.

Naval Oceanography Centers. Three Naval Oceanography Centers; the Naval Western Oceanography Center (NAVWESTOCEANCEN) Pearl Harbor, HI, Naval Eastern Oceanography Center (NAVEASTOCEANCEN), Norfolk, VA; and Naval Polar Oceanography Center (NAVPOLAR-OCEANCEN)

Suitland, MD; utilize the basic and applied numerical products from the FLENUMOCEANCEN to provide tailored fleet air-ocean environmental broadcasts as well as support in response to specific requests by the operating forces and shore establishment. The NAVWESTOCEANCEN is responsible for the provision of an air-ocean environmental service in the Pacific and Indian Ocean areas; NAVWESTOCEANCEN is responsible for the Atlantic and Mediterranean areas; and the NAVPOLAR-OCEANCEN provides an environmental forecasting and warning service for the Arctic and Antarctic areas. The Naval Polar Oceanography Center also supports and operates a NAVY-NOAA Joint Ice Center which provides analyses and forecasts of sea ice conditions to the civilian community as well as the military.

Naval Oceanography Command Centers. There are two Naval Oceanography Command Centers (NAVOCEANCOMCENs). NAVOCEANCOMCEN Guam assists NAVWESTOCEANCEN in the provision of air-ocean environmental services in the western Pacific and Indian Oceans. NAVOCEANCOMCEN Rota, Spain assists NAVEASTOCEANCEN in the provision of air-ocean environmental services for the Mediterranean area. Both centers utilize the basic and applied numerical products from the FLENUMOCEANCEN to provide tailored fleet air-ocean environmental broadcasts and support in response to specific requests by the operating forces. NAVOCEANCOMCEN Guam has an additional responsibility for the operation of a "Joint Typhoon Warning Center" (with the Air Weather Service of USAF) and for the provision of tropical cyclone warnings in the western Pacific and Indian Oceans, including the public of Guam in the Trust Territories.

Naval Oceanography Command Facility. The three Naval Oceanography Command Facilities (NAVOCEANCOMFACs) at Jacksonville, FL; San Diego, CA and Yokosuka, Japan provide limited area (as individually assigned) local and fleet aviation environmental services. They command assigned detachments and insure that the quality of fleet air-ocean environmental services provided by them meets required technical standards.

Naval Oceanography Command Detachments. There are 48 Naval Oceanography Command Detachments (NAVOCEANCOMDETS) strategically located throughout the world. They are situated near supported commands in order to provide a more direct and personalized service. Each is established under an Officer-in-Charge or a Chief Petty Officer-in-Charge who reports to a designated shore/field activity. Almost all of these detachments are structured to provide direct fleet air-ocean environmental support, including specialized aviation services, within their local areas. A small number (3) is oriented to provide specific technical support to the Naval Oceanography Command, and other Navy commands and units, as appropriate. This includes such functions as management of the

Navy's climatological program and liaison and coordination at Air Force bases for the inter-service exchange of air-ocean environmental data and products.

NAVOCEANO. The Naval Oceanographic Office (NAVOCEANO) is responsible for the maintenance and repair of meteorological and oceanographic equipment and for management of the Naval Oceanography Command's environmental training program for Navy enlisted personnel. It also commands the NAVOCEANCOM detachments at Naval Reserve and Naval Air Training Air Stations. A major function of the Naval Oceanographic Office, however, is the conduct of global oceanographic and hydrographic survey operations in response to specific Navy and Department of Defense requirements.

The Navy is continuing to cross-train its former meteorology and oceanography specialists in order that air-ocean environmental problems may be more adequately addressed. This training program continues to reflect the Navy's interest in the total maritime environment of the world's oceans in which it must operate. This interest reflects, in turn, the increasing sophistication of the Navy's ships, submarines and aircraft; their weapon and sensor systems; and command control systems: all of which are becoming more and more sensitive to the composite air-ocean environment. Technology is being applied as rapidly as possible to improve the effectiveness and efficiency of Naval Oceanography Command Operations and, in turn, of the fleet. Significant developments include the initial operational capability of the Naval Environmental Display Station (NEDS) and of the Satellite Processing Center. NEDS units are installed and operating at the FLENUMOCEANCEN, Monterey, CA; the three NAVOCEANCENs (East, West and Polar), the two NAVOCEANCOMCENs (Rota and Guam), and in the National Military Command Center at the Pentagon. The primary functions of NEDS units are transmission, receipt, storage, manipulation and display of graphic, alphanumeric and satellite data. NEDS capabilities include the multi-colored visual display of environmental parameters that significantly improves the ability to evaluate and forecast air-ocean environmental conditions of tactical significance to the operating forces. When fully operational during 1980, NEDS installations will permit the removal of many Naval Oceanography Command computers which have become obsolete and expensive to maintain. The NEDS is compatible with the Air Force automated COMEDS system and efforts are underway to provide for compatibility with the National Weather Service AFOS system. This will facilitate the existing exchange of data, products and services. It is planned that all Naval Oceanography Command activities and detachments, Navy ships with embarked air-ocean environmental units and major Fleet command and control centers will be provided a NEDS capability over the next several years.

The Satellite Processing Center (SPC) is a computerized facility within the FLENUMOCEANCEN, Monterey, CA, designed to

process data from the Department of Defense satellite and selected national environment satellite systems to meet specific Navy requirements. An initial operational capability has been achieved.

Current plans called for the upgrading of the primary computer system at the FLENUMOCEANCEN, Monterey, CA in November 1980. This will permit generation of the sophisticated air-ocean environmental products needed to support the increasingly complex weapon and sensor systems that are being introduced into the fleet, and will in turn enhance the force-multiplier effect of those new systems in matching Russian naval numerical superiority.

UNITED STATES AIR FORCE

The Air Weather Service (AWS) of the Military Airlift Command (MAC) is tasked by Air Force Regulation (AFR) 23-31 to provide environmental services to the United States Air Force and Army. Its primary mission is to support Air Force and Army combat operations in wartime. During peacetime, AWS prepares for its wartime role by providing or arranging daily staff and operational weather support to its military customers. AFR 23-31 also defines certain related environmental and scientific support requirements to other DOD and US Government agencies. Collection, processing, and dissemination of atmospheric and space environmental data and weather modification are intrinsic to such support.

The Bureau of the Budget Circular A-62, 13 November 1963, divides meteorological services into two types, basic and specialized. Although involved in both services, AWS is strongly oriented towards specialized services.

The overall objective of the Air Force meteorological research program is the development of techniques and equipment for observing and predicting meteorological conditions that affect military operations. Requirements for research and technology in meteorology are expressed in "Air Force Technology Planning Objectives, Research Objectives, Technology Needs, General Operational Requirements and Development Goals." In addition, the Air Weather Service provides guidance and direction in the form of geophysical requirements and research objectives. Emphasis is on automated direct and remote sensing systems, weather satellite imagery analysis and application, shortrange terminal forecasting and numerical prediction techniques, climatological studies and cloud and precipitation physics. Also, research and development for the Defense Meteorological Satellite Program are included.

In the area of weather radar and remote sensing, the principal effort is on the development of improved instrumentation, preferably automated, for the measurement, processing, display and analysis of meteorological information. In FY1980-81, advanced weather radar concepts will be investigated to meet Air Weather

Service long-range requirements. Application of FM-CW Doppler radar techniques to detection and warning of hazardous wind conditions over air bases will be initiated based on the results of experimental studies. A survey of ground-based and aircraft lightning detection and warning systems will have been completed and the recommendations for equipment development will be implemented. Studies of the feasibility of microwave and electro-optical techniques for indirect sensing of aircraft turbulence, low-level winds, temperature and humidity will be made.

Radar diagnostic techniques for the operational detection of significant features in storms indicative of their development, motion, and severity will also be developed. In FY1980-81, conventional radar and Doppler radar data will be analyzed to identify features of hail-producing storms. Coherent optical and microwave radar polarization diversity techniques will be developed for possible use in measuring number concentration, size distribution, phase and shape characteristics of cloud and precipitation particles that affect aircraft, missile, electro-optical and communications systems.

Automated ground-based observing and short-range forecasting will continue to be a major effort in FY1980-82 with the continued development of computer-controlled meteorological sensing, processing, and display capability for use at fixed bases and mobile tactical airfields. Automation of 0- to 3-hour forecasts of cloud base height and low-level wind shear will also be a goal. To further improve the quality of short-range forecasts, analysis and use of satellite imagery will be optimzed. In FY1980, algorithms were developed and tested for specifying types of cloudiness and precipitation from satellite imagery. In FY1981, at least one forecasting system based on satellite data will be tested. In a related effort directed toward improving satellite system technology, investigation of infrared and millimeter wave instrumentation and techniques for application to atmospheric sounding, together with theoretical studies of methods for temperature retrieval from IR radiance will be continued.

There is a continuing requirement for specialized climatological information for use in the design or operation of military equipment. In FY1980 models of space and time variations of atmospheric density, temperature and wind for altitudes up to 90 km and a Northern Hemisphere areas of probabilities of precipitation free lines-of-sight were under construction. In addition, theoretical models were developed for use in determining the probability of favorable weather in all phases of a military operation. In FY1981, a global climatology of the probability of exceeding specified rainfall rates will be prepared.

Basic research is performed to improve the accuracy and speed of numerical weather prediction. In FY1981, fundamental investigations will be carried out on the interaction of mesoscale

and synoptic scale circulations, on the effects of computational resolution on accuracy of weather predictions based on mathematical models, and an optimal computational resolution for prescribed densities and frequencies of available thermodynamic energy for a moist atmosphere and on development of a low-order model to investigate the generation of such energy and its conversion into kinetic energy. Finally, a comparison will be made of the accuracy and efficiency of finite-difference and spectral methods in numerical weather prediction models and the effects of sub-gridscale processes will be incorporated in them through improved selection of parameters.

Research also will be conducted on large-scale cloud systems. In FY 1980, instrumented aircraft were used to extend the data base requred for statistical summaries of hydrometeor size spectra, mass spectra and crystal habit. Two new aircraft instruments designed to obtain water content values in the melting layer were evaluated. In FY1981, a cirrus particle mass detector will be flight tested. Data from satellites and other platforms will be used to develop methods for remotely sensing hydrometeor size distribution and phase.

In addition to the research efforts described above, the Air Force Office of Scientific Research has established programs to take advantage of scientific capabilities within universities and commercial firms. This research is concerned with specifying, modeling and predicting meteorological factors that may affect Air Force operations. In FY1980-81, investigations in atmospheric electricity, cloud physics, aerosols, and medium-scale meteorological systems will be supported.

Regarding the Defense Meteorological Satellite Program, in FY 1980, development of the microwave special sensor payload was continued. This sensor will provide the capability to identify areas of heavy precipitation and to assess soil moisture content. In addition, development of the ground system changes which provide encryption of both the satellite command and control system and the data relay system was continued. In FY1981, the satellite development necessary for operational shuttle compatability and transition in FY1986 will be continued in addition to the continuation of the microwave imager and encryption work described above. System engineering and analysis efforts necessary to support launch and in-orbit operations will continue in FY1981.

Meteorological Services.

The general functions involved in providing meteorological services include observing current weather, communicating weather data and information, preparing analyses and forecasts, issuing and disseminating warnings and forecasts and archiving weather information for ready retrieval.

The first of these functions, observing, comprises four programs: surface, upper-air, radar and meteorological satellites. Surface observations are taken by AWS personnel in support of analysis and forecasting but primarily for other specialized applications. Observations at both Air Force and Army locations (fixed and tactical) are manually obtained; some atmospheric elements being sensed by instruments and some directly by the observer. The observations are made available locally and are collected by the Automated Weather Network (AWN), a high-speed communications network, for transmission to the Air Force Global Weather Central (AFGWC), as well as to other military and civil locations worldwide. In FY1980, there were 113 AWS surface observing facilities/locations in the continental United States (CONUS) and 65 overseas.

Upper air observations provide the major input for numerical analysis and forecasting. Most of this information is obtained from U. S. civil and foreign sources as well as rawinsonde (fixed and mobile) and rocketsonde facilities operated by AWS. Additional upper air information from data-void areas is obtained from U.S. Air Force weather reconnaissance aircraft and in-flight pilot reports from both military and civil aircraft.

The Air Force performs aerial weather reconnaissance in support of U.S. military and civil requirements. Thirteen WC-130 aircraft are provided by MAC's Aerospace Rescue and Recovery Service (ARRS) and seven by the Air Force Reserve (AFRES). Aerial reconnaissance weather officers and dropsonde operators are provided by AWS (for the ARRS aircraft) and the AFRES (for the AFRES aircraft).

The weather radar is a principal source of information for making short-term warnings of severe weather. AWS operates 91 weather radar sets (16 overseas). Two of the Continental US (CONUS) sets are a part of the U. S. basic weather radar network; 13 are used in a backup capacity. Eleven of the AWS weather radars are used to support the National Hurricane Operations Plan.

The final observing program is the meteorological satellite. The Defense Meteorological Satellite Program (DMSP), is an operational satellite system managed by the Air Force for DOD, to support military requirements worldwide. The DMSP was designed and developed under a total systems concept to provide the specialized meteorological data required by DOD. Sensors, communications and ground processing facilities were developed to provide maximum responsiveness to the military decision-maker. The DMSP normally consists of two satellites in an approximately 830-kilometer, sun-synchronous polar orbit with a period of 101 minutes. The DMSP provides visual and infrared (IR) images of the entire globe plus temperatures and moisture soundings, auroral electron counts and other specialized meteorological data to the AFGWC. It also

supplies direct, real-time readout of regional cloud-cover information (visual and IR) to selected military locations around the world.

The present DMSP spacecraft series (Block 5D) uses an operational line-scan system (OLS). The OLS is a digital system designed to format and store visual, IR and special sensor data. The visual sensors detect the brightness of reflected solar illumination from 0.4 and 1.1 micrometers. The IR sensors measure emitted radiation in the 8 to 13 micrometer spectral band. Beginning with the fourth Block 5D series spacecraft, the infrared spectral window was narrowed to 10.5 to 12.5 micrometers to reduce the amount of absorption by ozone and water vapor. The visual sensors were selected to optimize distinction among clouds, ground and water. Electronic circuitry converts the sensed infrared energy directly into equivalent blackbody temperaure, making temperature the displayed parameter. IR and visual imagery are obtained at near-constant cross-track resolutions of 0.5 km (Fine Data) and 2.8 km (Smooth Data). The Block 5D satellite incorporates selective redundancy and other reliability improvements to achieve longer operational life. It uses both stellar and inertial references, together with on-board processors, to maintain stability and pointing accuracy and is significantly better than earlier DMSP satellites.

The DMSP communications and ground processing systems are designed to produce usable products within five minutes after the data stream ends. The central processing facility at the AFGWC is linked to the DMSP Command readout facilities via a real-time satellite link. High-quality imagery is displayed for manual use and can be input directly into the AFGWC computers. There, it is converted into cloud parameters and collated with conventional meteorological data to produce a comprehensive three-dimensional numerical cloud analysis. The Air Force system for direct, local readout of DMSP data is a self-contained, air-transportable unit, capable of worldwide deployment in a matter of hours.

The usefulness of these observations of meteorological elements depends on an effective communications network. The USAF global weather communications system provides for the collection of meteorological data (alphanumeric and pictorial), delivers these data to weather centrals and forecast facilities and distributes centrally-produced products to the user. Conventional weather teletype networks, high-speed automated digital facilities, long-haul point-to-point teletype data circuits, facsimile networks and radio and teletype intercept facilities constitute the Air Force Communications Command (AFCC) system.

The Automated Weather Network (AWN) is the backbone of military weather communications, using high-speed computers interconnected with 2400-4800 baud circuitry to delivery foreign and domestic weather data to designated users. Data-intercept sites in key overseas areas obtain foreign weather broadcasts for AWN delivery to the AFGWC. The USAF AWN also delivers these data to the Navy's Fleet Numerical Oceanography Center and to NOAA's National Meteorological Center. Overseas collection and dissemination teletype networks are driven by the AWN Automatic Digital Weather Switch (ADWS) computers. The CONUS ADWS at Carswell AFB, TX, drives the CONUS Meteorological Data System (COMEDS) and special teletype systems within the CONUS, an integral part of the weather collection and dissemination function. COMEDS serves as the prime communications system for the collection and dissemination of military Notice to Airmen (NOTAM) message traffic to all DOD users.

The Weather Facsimile Switching Center (WFSC) at Offutt AFB, NE, is the hub of the facsimile system, providing graphic/pictorial data to worldwide military users. WFSC drives the separate networks serving the CONUS, Europe and the Pacific, using InterData 50 (ID 50) computers to store and forward required products.

Data requirements of AWS units worldwide are met through a combination of routine data delivery and an Automatic Response to Query (ARQ) system to satisfy their needs for mission-essential, non-routine weather data.

In addition to communications responsibilities, AFCC maintains the AWS meteorological equipment. The command also operates and maintains the Air Force facilities of the Defense Meteorological Satellite Program. Organizational maintenance is funded through the host base; intermediate maintenance is funded by AFCC.

Many analysis and forecast requirements for Air Force and Army customers are met by the AFGWC at Offutt AFB, NE. The AFGWC employs over 700 scientists and technicians (military and civilian) and uses five UNIVAC computer systems. The computer-based operation of AFGWC uses a build-and-apply concept. Worldwide weather data are relayed to AFGWC via the high-speed AWN and blended with civil and military meteorological satellite data to construct a real-time integrated environmental data base. Scientific computer programs further digest the data to construct models of the atmosphere and forecast its future behavior. Final tailoring of the data is accomplished for application to the specific problem of the decision-maker. During FY1980, three UNIVAC 1108s were replaced by two 1100/81s to provide the computational capability needed to meet the increased demand for tailored in-flight weather profiles and command control support.

In the Federal Plan for Cooperative Backup Among Operational Processing Centers, AFGWC is designated as backup for the NWS AFOS system, NMC's computational center for commercial aviation wind forecasts, and NWS's facsimile networks. In addition, the National Severe Local Storms Operations Plan designates AFGWC as the backup for the NWS's National Severe Storms Forecast Center.

The USAF Environmental Technical Applications Center (USAFETAC), Scott AFB, IL, provides environmental data to support the U.S. Air Force, U.S. Army, and other government agency requirements for assessments of natural environmental effects on military plans, weapon systems, facilities and intelligence activities. USAFETAC collects environmental data from its parent organization (AFGWC), then sorts, checks and stores these data. USAFETAC operates a facility collocated with the National Climatic Center in Asheville, NC for the exchange of climatic data with civil agencies. USAFETAC typically stores worldwide weather observatins, surface weather analyses, upper atmosphere analyses and unique three-dimensional cloud analyses extracted from meteorological satellite imagery. From these stored data, they provide standard climatological products and specialized products such as atmospheric profiles, soil moisture assessments, and probabilities of cloud-free line-of-sight.

AWS contributes to the unique global needs of military aviation and makes its information available to civil aviation. It provides pre-mission briefings and air-ground radio services, tailoring its observations, forecasts and warnings for unique military aircraft requirements.

An aspect of special emphasis in military weather support is the need to provide adequate decision-assistance to commanders and resource managers. To fulfill this requirement, designated AWS personnel serve as part of the working staff of supported Air Force and Army units. In this capacity, they identify all weather-sensitive areas of the supported operation, monitor the weather service provided in these areas, and provide expert advice when weather threatens to restrict training or combat operations. This AWS effort helps insure that Air Force and Army units are able to fulfill their missions in spite of adverse weather, and it results in efficient expenditure for weather resources by gearing them to mission-essential support needs.

The Air Force and Army require worldwide meteorological services to support specific operational and planning activities. Military users require meteorological information directed to the needs of weapon systems being developed or used; command and control systems; Army firing units; research, development and evaluation; training and deployment of military forces and contingency operations.

To provide these services, AWS maintains analysis and forecasting facilities in the United States and abroad, including AFGWC and tactical forecast units in Europe and Alaska. Special centers, such as USAFETAC and the Joint Typhoon Warning Center at Guam, also fulfill unique military meteorological requirements. Similarly, AWS observation facilities obtain data in direct support of special military operations.

Aerial weather reconnaissance plays a vital role in specific military operations. Essential weather observations from inside/outside tropical cyclones, along tactical deployment routes, in-flight refueling and missile/satellite recovery areas are obtained by weather reconnaissance aircraft. In addition, these aircraft provide supplemental vertical soundings over data-sparse ocean areas.

AWS, through AFGWC, directly supports DOD Special Strategic Programs, the National Command Authority, the National Military Command System and the National Security Agency. Tailored environmental support products are disseminated to these customers worldwide.

In support of tactical military operations, AWS support is designed around three basic components: the Centralized Production Units (CPUs), Tactical Forecasts Units (TFUs) and Weather Teams (WETMs). The CPUs consist of the Air Force Global Weather Central (AFGWC), the United States Air Force Environmental Technical Applications Center (USAFETAC) and the Automated Weather Network (AWN). The CPUs provide direct, mission-tailored and routine support through designated communications circuitry, including the AWN, to the TFUs and WETMs. The TFU represents a vital capability of weather support force by providing tailored weather service to in-theater decision makers. These units provide forecast services and products for combat activities in a specific geographical area, tactical operation, or exercise, through relay of CPU products, tailoring of operational support products and local generation of mission support products. WETMs are the basic units supporting customers in a tactical theater and provide surface and upper air observing, briefing and limited forecasting support. Tactical Weather Equipment (TACMET) and a communication broadcast system are being developed to provide weather data to the TFUs and WETMs. Main components of TACMET will be the Tactical Weather System (TWS), tactical weather radar (AN/TPS-68), tactical meteorological satellite direct readout terminals (Mark IV), and tactical observing kits (TMQ-22 and Belt Weather Kits). Main components of the broadcast system will be reliable, secure, tactically deployable send and receive teletypes; reliable, secure, tactically deployable receive facsimile sets; and at least three broadcast stations.

AWS integrates Army weather support into its overall support concept. AWS personnel are trained and oriented on applicable Army organizations, concepts of operations and weather sensitivities

required to satisfy Army environmental requirements. AWS support units are aligned and integrated with the Army intelligence organization. Support products are in a form which is directly usable and understandable by Army personnel, and are integrated into Army communications systems. Mobile and fixed meteorological equipment for use in Army support is programmed by AWS. In a tactical environment, direct forecast support is normally provided down to Division level, to Armored Calvary Regiments and to Separate Brigade Headquarters. Observer support is normally provided at these levels and Brigade levels within the Division.

AWS provides meteorological support to the Nation's space and missile programs. This includes a wide range of meteorological observations at the Air Force Eastern Test Range and the Kennedy Space Center. AWS also provides the forecasting service for NASA's unmanned launches at the Kennedy Center.

AWS provides specialized meteorological services for the Space and Missile Test Center at Vandenberg AFB, CA, and the Pacific Missile Range, which includes Pt. Mugu and San Nicholas Island, CA, and Barking Sands, HI. AWS also supports the White Sands Missile Range, NM, the Kwajalein Missile Range and other DOD research and test facilities.

Modernization Programs.

USAF and Army operational requirements for environmental support are the basis for all AWS actions to improve existing or acquire new capabilities. AWS assesses these requirements and attempts to satisfy them through either hardware acquisitions or technique development.

AWS plans to modernize its base-level weather support systems. This includes an Automated Weather Distribution System (AWDS) and an Advanced Weather Radar (AWR). Both have been approved by the Air Force and have received limited future funding.

AWDS will perform two major functions, automated surface observing and data-handling. It will incorporate the latest state-of-the-art data processing, communications and display technologies. The observing function will take, display and transmit (long-line and locally) surface weather observations. The Federal Coordinator is exploring the feasibility of joint development and acquisition of this component by several Federal Agencies. The data-handling function will maximize forecaster capability by eliminating most of the labor-intensive tasks associated with forecasting. A modular architectural design will permit AWDS to be operated in a fixed or mobile environment and minimize staffing requirements. Initial installation is planned for late 1985 with completion of overseas and tactical installations by 1989. AWDS will be able to receive information from the National and Navy Weather Service systems.

AF NEXRAD will be an automated, digitized, S-band Doppler system that will be jointly developed, procured, operated and maintained by the USAF, NOAA and FAA within the CONUS and by the USAF overseas. The system will be designed to incorporate the latest technological advances in Doppler radar, data processing, communications and display modes. The CONUS AF NEXRAD network will satisfy weather radar requirements in support of the general public, the military and the entire spectrum of the aviation community. Installation of the AF NEXRAD is planned between 1981 and 1990.

FY1981 funds have been requested to modify the current AWS AN-FPS-77 weather radars by replacing transmitter and receiver circuitry and antenna components. This action is needed to ensure continued logistics and maintenance support of this radar until AWR is operational.

AWS, through the Air Force Logistics Command, has ongoing programs to upgrade its present weather reconnaissance capability by improving system reliability and maintainability. Prototype testing and replacement of components for the AN/AMQ-29 dropsonde recording system was scheduled for FY1985. Long range plans call for an improved weather reconnaissance and dropwindsonde capability. These latter two programs have been approved by the Air Force, but lack funding. The feasibility of using off-the-shelf equipment and in-house development of these capabilities is under examination within the Air Force, in conjunction with NOAA, in an attempt to minimize costs.

The Air Force is modifying airfield meteorological equipment to replace obsolete vacuum tube components with solid-state electronics. These actions will materially reduce logistics and maintenance costs and increase equipment in-commission time.

A one-million dollar contract was awarded in July 1978 for 344 modification kits to convert inventory transmissionmeters (AN/GMQ-10) to solid state circuitry. Delivery to AWS field units is expected to be completed in FY1981.

In the area of atmospheric pressure measurement, USAF has converted from wide-bore, mercurial barometers to dead-weight piston gauges used as regional primary pressure standards. Funds were approved in FY1979-1980 to procure a digital barometer and altimeter setting indicator. The unit will be solid-state, easily transportable, highly accurate and mercury-free. This will eliminate base weather station mercurial barometers and their mercury contamination health hazard. In future years the Air Force plans to replace its temperature/dewpoint and wind-measuring equipment and upgrade its cloud-height measuring system.

A significant improvement in the interaction between man and machine to provide accurate and comprehensive meteorological forecasts is the planned acquisition in FY1981 of an interactive

processing and display system (IPADS) for use at the AFGWC. In March 1979, the Harris Corporation was awarded a contract for the acquisition of a Satellite Data Handling System (SDHS): the contract included an option for the acquisition for IPADS. The two complementary systems will provide 35 computer consoles (29 IPADS, 6 SDHS) to be used by AFGWC weather technicians to interact directly with the AFGWC computers, thereby eliminating physical handling of hardcopy information (plotting, overlaying, tracing, posting, sorting, etc.) through automation. Meteorological satellite imagery will be electronically integrated with conventional meteorological data to construct a three-dimensional model of the true state of the atmosphere.

APPENDIX D

DEPARTMENT OF ENERGY

Meteorological service activity of the Department of Energy is described in Section 1. DOE does not support any reportable program in supporting research.

APPENDIX E

DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION (FAA)

SUPPORTING RESEARCH AND DEVELOPMENT.

The Federal Aviation Administration (FAA) is continuing to develop and test automated systems for making and transmitting surface aviation observations.

Field tests of a Low Cost Automated Weather Station (ALWOS) were initiated in FY1980. The results of this test, and earlier tests of an Aviation Weather Observation System (AV-AWOS), will provide guidance for the development of a joint (Federal Aviation Administration, National Weather Service, Department of Defense) specification for a total Automated Weather Observation System (AWOS) that is expected to lead to joint procurement of equipment to meet the mission requirements of the separate agencies. This specification will complete the research and development phase of this effort.

Another FY1980 effort was the test and evaluation of various commercially developed automated weather observation systems to determine if the FAA could certify them for use in the National Airspace System in accordance with Advisory Circular AC-91-54. Several such systems met the criteria and were certified by the agency. It should be noted that these systems do not measure all of the parameters required for a complete surface aviation observation.

In FY1981, the principal effort will be directed at developing the special features required for insuring that automated weather observation systems can meet the special environmental requirements for operations on off-shore platforms. Field testing of the ALWOS will be completed.

In FY1980, a Joint System Program Office (JSPO), with National Oceanic Atmospheric Administration (NOAA), Department of Defense (DOD), and FAA participation, was established at NWS Headquarters to develop a national Doppler weather radar severe weather detection and distribution system (NEXRAD). A detailed Program Development Plan (PDP) and joint operational requirements are nearing completion. Field testing of the utility of Doppler radar in the terminal area was continued at the National Severe Storms Laboratory (NSSL) in Oklahoma. Additional severe storm exploratory flight penetration tests were conducted.

In FY1981, participation in the NEXRAD JSPO will be continued and a joint experimental test facility will be established. Multiple system concept contracts will be initiated with industry

leading to several development contracts in FY1982. Doppler developmental component testing will be continued at NSSL and the National Aviation Facilities Experimental Center (NAFEC). In addition, an operational test-bed facility will be initiated to test the validity of the various Doppler radar system products in Air Traffic Control (ATC) and Flight Service Station (FSS) environments.

Under the FAA's Wind Shear Program, airborne solutions to low level wind shear have been developed. Flight testing of low cost ground speed concepts was completed in FY1980. As a result of the extensive manned simulation and flight test effort, a Notice of Proposed Rule Making was issued in FY1980, requiring airborne wind shear detection and avoidance equipment for air carrier aircraft. In FY1981, improvements in the algorithms to drive the flight director will be expanded to include automatic flight controls for possible wind shear encounters.

Testing of the pulsed Doppler radar prototype for detection of wind shear and turbulence in clear air was completed in FY1980. While results appear promising, additional development work will continue into FY1981. Systems costs preclude using radar solely as a wind shear detection device; however, the combining of the overall terminal weather detection requirement may prove to be economically practical.

During FY1980, a test was initiated at Atlanta of the effectiveness of adding pressure jump measurements to the operational low level wind shear alert systems. The evaluation of the combined system will continue into FY1981.

In FY1980, work was completed on gathering observational data on the icing environment below 10,000 feet as a basis for provision of air-worthiness standards to certify helicopters for all-weather operations.

Under a joint agreement, the FAA and the National Weather Service (NWS) continued to develop radar data processing techniques for automated short range forecasts of thunderstorms and associatd hazards in the 0-2 hour time period. The thunderstorm forecast techniques were tested in a simulated operational environment for use by Center Weather Service Units (CWSU) in assisting air traffic controllers to help pilots avoid hazardous convective weather.

In FY1981, operational techniques for the 0-2 hour forecast of thunderstorm cell development and motion will be field tested and the usefulness of Doppler weather radar data and other meteorological data to improve forecasts of thunderstorms and related weather conditions will be investigated.

NWS now routinely prepares and issues forecasts of non-convective frontal type wind shear. Work will continue in FY1981 to develop a capability to forecast thunderstorm-related wind shear.

In FY1979, FAA issued an Aviation Weather System (AWES) Preliminary Program Plan,, designed to improve the aviation weather support provided to the National Airspace System (NAS) and its users through the 1980s and beyond. In FY1980, this Preliminary Plan was updated and published as an approved plan.

In FY1980, the AWES System Functional Description was completed. Tests and evaluation of the new designed improvements for use by meteorologists and weather coordinators in the Enroute Centers were conducted at NAFEC. These improvements will be used to update weather service in centers and to automate the handling and dissemination of weather information and pilots' reports. In the terminal area, a joint interagency (NOAA, FAA, DOD, and NASA) program PROFS (Prototype Regional Observing and Forecast System) to improve real-time weather services to critical terminal operations was initiated in the Denver, Colorado, area.

In FY1981, the Detailed Design Specifications for the FAA's weather system (AWES) will be initiated. Initial operational testing of various system components will be conducted at NAFEC. The results of this testing will be utilized to upgrade overall services and to provide for more rapid distribution of surface observations, and increase the speed of weather data transmissions. Participation in the PROFS program will be continued, with initial tests of the use of fine-scale data in ATC functions in the Denver area.

FAA plans to automate at least 43 of the most active Flight Service Stations (FSSs). The initial level of automation will consist of a computer system that will be a subset of the ultimate system design for the upgraded automated Flight Service Automation System. The software will be a relatively simple version that will permit automatic file updating, retrieval, and display of alphanumeric weather and aeronautical data, flight plan entry, and flight plan processing. Each computer system will have a dedicated data communications line from the FAA Weather Message Switching Center (WMSC), and the Automated Service B Data Interchange System (ABDIS).

The upgraded automation system will provide full specialist automation capabilities. Two Aviation Weather Processors (AWPs) will be added. The AWPs will interface with the WMSC for alphanumeric weather data and with NWS's National Distribution Circuit (NDC) for graphic weather products. Each of the 20 computer systems will then receive all alphanumeric and graphic data directly from an AWP. Weather radar data will be received from selected NWS/FAA radars and stored in each computer system for instant retrieval. This will provide the necessary automation capacity to meet forecast service demands through 1995 for FSS specialist operating positions and for self-briefing access features for pilots throughout the country. Details are given in the Master Plan for Flight Service Station Automation Program, January 1978.

Proposals for procurement of the initial level of automation were received in late FY1978. In FY1980, three competitive contracts were awarded for the verification of the contractors' upgraded automation system design; and production of a first package of the initial level system software.

In FY1981, a single contractor will be selected for production of 16 Model-1 systems, two AWPs, up to five Model-2 systems, and development of long-term Model-2 enhancements, known as Model-3.

Other major R&D efforts in the FSS program are to develop techniques that will permit pilots to have direct access to the FSS automation data base.

The approach is as follows:

- Develop computer-generated voice response capability to touchtone inputs; Voice Response System (VRS).
- Develop computer voice recognition capability.
- Develop automated flight plan filing capability via telephone with touchtone or voice inputs.
- Integrate voice response/voice recognition/flight plan filing and Pilot Automatic Telephone Weather Answering Service (PATWAS) into a National System design for pilot self-briefing.
- Develop the concept of pilot self-briefing via interactive coupling of home television sets with the FSS automation data base
- Jointly develop, with the NWS, new formats and techniques for generating, processing, and delivering aviation weather products to pilots for preflight and inflight applications.

An operational test of pilot acceptance and use of computer-generated voice response systems was conducted at Columbus, Ohio, in FY1980.

The authority of the FAA to perform research and development functions in the aviation weather area is contained in the Federal Aviation Act of 1958.

METEOROLOGICAL SERVICES

Center weather service units will be in place in the 20 air route trafffic control centers within the 48 contiguous states and the one in Alaska by the end of FY1980. In each of these units there are three National Weather Service meteorologists providing service to the air traffic controllers and to other FAA facilities for two 8-hour shifts per day. IN FY1981 the number of meteorologists is to be increased to four. FAA reimburses the

National Weather Service for the salaries of the meteorologists as well as providing end-year staffing positions from its resources.

To assist the meteorologist in the center weather service units, a radar remote weather display program was initiated in FY1980. This system displays on a television screen six levels of precipitation intensity in six different colors, as detected by National Weather Service. The program also includes a display for the en route flight advisory service position in 44 of FAA's flight service stations. The installation of equipment will be completed by mid-FY1981.

The installation of the low level wind shear alerting system is continuing and will be completed at approximately 60 airports by FY1981. This system uses wind sensors (anemometers) near the approach and departure ends of the runways and compares the readings from these sensors with a centerfield wind sensor. When a wind shear is apparent from this comparison, the tower controller is alerted and the information is passed from the controller to the pilot approaching the airport or preparing for takeoff.

Two corporations are under contract to FAA to produce an engineering model of a cloud height indicator system. These engineering models are to use the laser technology in measuring cloud height. A production contract is to be awarded to one of these contractors based on the best combination arising out of the proven performance of the engineering model systems. The production contract is expected to be awarded in FY1980, and installation of the production systems will be initiated in FY1981. This cloud height indicator is a prime candidate for use in automated surface weather observing systems being developed jointly with the Departments of Commerce and Defense.

During FY1981, FAA plans to install automated surface weather observing and reporting systems at some general aviation airports. These systems will give the pilot, via radio, the wind direction and speed as well as the altimeter setting. These airports are those not presently having any weather observing service but which do have an approved instrument approach from navigational aids. With this automated information, the pilot can safely make an instrument approach to the minimum altitude permitted allowing more efficient and safe use of the airport.

U.S. COAST GUARD

The Coast Guard does not manage any supporting research programs in meteorology.

The Coast Guard is authorized to cooperate with NOAA in the observation and dissemination of weather information by 14 USC 147.

APPENDIX F

ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA's applied research is in areas of air quality dispersion model development, evaluation, verification and application; development and application of air pollution climatology; determination and description of pollutant effects on atmospheric parameters; and determination of meteorological effects on air quality. Dispersion models for inert and reactive pollutants are under development and evaluation on all temporal and spatial scales. Particular emphasis is being given to the development of a regional ozone model and a complex terrain model. These programs, initiated in FY1979 and FY1980, are also prime research projects in FY1981. Planetary and urban boundary layers are under development for use with air quality dispersion models. Development of air pollution climatology continues in cooperation with the National Climatic Center, including development of plume rise and inversion climatologies.

Air quality forecasting techniques are under development using NWS/NMC forecast products. Examination of the relationship between meteorology and air quality, with emphasis on ozone and sulfates, continues. The effects of air pollutants on atmospheric parameters, such as visibility and precipitation chemistry, are also under continuing investigation.

APPENDIX G

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

The NASA Weather and Climate Program is an integrated effort to develop new technology, hardware, applications and theory for improving the quality of meteorological information to meet national needs. For convenience in management, the NASA program is divided into three components:

- Development of coordinated space and ground systems for severe storm detection, prediction and warning.
- Development and application of space technology to improve forecasting for periods up to 2 to 3 weeks.
- Investigation of the potential for monitoring and predicting climate changes.

In the study of severe storms, NASA is using space, aircraft and groundbased technology to obtain an improved understanding of the dynamics of severe storms such as thunderstorms, tornadoes, hurricanes and typhoons. Development of models and forecast techniques using satellites, aircraft and other data to improve the prediction of severe storms is underway. This research also will lead to the specification of new space capabilities for severe storm observation, detection and prediction. The NASA-developed VISSR Atmospheric Sounder (VAS) was launched in August 1980 on the Geostationary Operational Environmental Satellite (GOES-D) to provide measurements of the vertical structure of temperature and humidity in the vicinity of severe storms. The maximum time resolution for clear sky conditions is sounding over a 750-km wide swath every 30 minutes with a maximum space resolution of 30 km . This is a step forward in developing a space capability for the detection and monitoring of these storms.

NASA is studying the feasibility of observing lightning from space. Numerous users of such data have been identified and their requirements are currently being evaluated by science and engineering teams representing an extensive interagency, university and national cross section. Field observations are being conducted to establish the information content of lightning-related emissions from the tops of thunderstorms. If the feasibility is proven, then a research sensor will be designed for a geosynchronous satellite.

Selected experiments will capitalize on the geostationary meteorological satellite capabilities for localized, adverse weather conditions. An experiment in improved detection and prediction of frost and freeze conditions in Florida, in cooperation with NOAA, will evaluate the results and determine the manner in which operational use will be made of this new capability.

The National Oceanic Satellite System (NOSS) is being developed by NASA under joint funding with NOAA and DOD. The primary purpose of NOSS is to provide a limited operational demonstration for monitoring and improving the ability to predict weather and ocean parameters including high wind and sea areas, ice conditions in polar areas, ocean thermal structure and currents. These parameters will be abstracted and delivered to the users in the form of timely data products.

A sophisticated information processing system Atmospheric and Oceanographic Information Processing System (AOIPS) has been developed by NASA and is in current use for research. This system can process satellite observations (as well as many other types of data) into false color image displays on a video screen. Image-color keys, time rate of image progression, horizontal scaling and so on, can be easily changed with a great deal of flexibility by the investigator. In this way, one researcher can discern and study a large number of interesting phenomena over their lifetimes. Such equipment development also leads the way to development of similar equipment for operational uses - especially for monitoring severe storm development and motion. This information forms a firm basis for storm warnings.

Specifically intended for improvement of conventional forecasting, is NASA's development of the TIROS-N, a third generation operational meteorological satellite. The first TIROS-N, launched in October 1978, was followed in May 1979, by another TIROS-N type satellie funded by NOAA and designated NOAA-A. TIROS-N model satellites will provide global monitoring of weather systems and highly accurate quantitative measurements of the atmospheric state. NASA will also develop advanced instrumentation for improvements to the TIROS-N series of satellites for improved atmospheric soundings, higher spatial and temporal resolution imagery and observations of the distribution and total content of atmospheric constituents such as ozone. TIROS-N spacecraft provide direct support to NWS and the international Global Atmospheric Research Program (GARP). NASA will participate in the analysis of GARP-produced data, particularly data acquired from space, and in interpretation and application of those data through the development of advanced techniques for modeling and prediction. Supporting GARP, in addition to the TIROS-N type low-altitude, Sun-synchronous satellite, were five geosynchronous satellites spaced over the Equator, three United States (SMS/GOES), one European (ESA - Meteosat), and one Japanese (GMS). NASA technology has been applied extensively in the development of the US spacecraft.

NASA climate research covers the long-term characteristics of the atmosphere-ocean-land system and will emphasize the understanding of the physical basis of climate. NASA efforts will be directed mainly toward climate modeling and the development of space-observational capability. Space data already gathered can yield information vital to national climate interests when

additional analyses and corroborative data are collected. These data include global total ozone measurements from Nimbus 4, 5 and 6; global precipitation, soil moisture, snow and ice cover from the microwave sensors of Nimbus 5 and important data on the Earth's radiation budget from Nimbus 6. These climate analyses will incorporate additional data on atmospheric constituents for Nimbus 7 and limited oceanographic data from SEASAT-A.

NASA studies, performed with leading climate scientific investigators and in conjunction with national planning for climate research, have served to identify climate modeling and data requirements that can now be measured on the required global basis by satellite techniques. One of these requirements is a global determination of the components of the Earth's radiation budget. The Earth Radiation Budget Satellite System (ERBSS) will be a three-spacecraft system designed to meet this need. Launching of the three spacecraft is scheduled for 1983.

The authority for NASA activities in meteorology ensues from the DOC-NASA basic agreement (July 1973) and OMB Circular A-62 (November 13, 1963).

ACRONYMS AND ABBREVIATIONS

ABDIS	Automated Service B Data Interchange System
ACPL	Atmospheric Cloud Physics Laboratory
ADWS	Automated Digital Weather Switch
AEPS	Automated Environmental Prediction System
AEW	Airborne Early Warning
AF	Air Force (USAF)
AFB	Air Force Base
AFCC	Air Force Communications Command
AFGWC	Air Force Global Weather Central
AFOS	Automation of Field Operations and Services
AFR	Air Force Regulations
AFRES	Air Force Reserve
AHOS	Automated Hydrologic Observing System
AIDJEX	Artic Ice Joint Experiment
ALWOS	Automated Low Cost Weather Observation System
AMR	Aircraft Microwave Refractometer
AMS	Automatic Meteorological System
AN/AMQ-29	Dropsonde Recording System (USAF)
AN/GMD-1	Military Upper Air Sounding System
AN/GMQ-10	Transmissometer (USAF)
AN/GUS-5	Laser Range Finder
AN/TMQ-31	Automatic Atmospheric Sounding Set
AN/TPS-68	Tactical Weather Radar (U.S. Air Force and Army)
AOIPS	Atmospheric and Oceanographic Information Processing System
APCL	Atmospheric Physics and Chemistry Laboratory
APT	Automatic Picture Transmission
AR	Army Regulations
ARGOS	French Data Collection System
ARQ	Automatic Response to Query
ARRS	Aerospace Rescue and Recovery Service
ARTCC	Air Route Traffic Control Center
ASL	Army Atmospheric Science Laboratory
ASW	Anti-Submarine Warfare
ATC	Air Traffic Control
AV-AWOS	Aviation Automated Observing System
AVHRR	Advanced Very High Resolution Radiometer
AWDS	Automated Weather Distribution System
AWES	Automated Weather System
AWOS	Automated Weather Observing System
AWN	Automated Weather Network
AWP	Aviation Weather Processor
AWR	Advanced Weather Radar
AWS	Air Weather Service

CAT	Clear Air Turbulence
CDA	Command and Data Acquisition
CDAS	Command and Data Acquisition Station
CDDF	Central Data Distribution Facility
CDMP	Cumulus Dynamics and Microphysics Program
CEAS	Center for Environmental Assessment Services
CO_2	Carbon Dioxide
COMEDS	Continental U.S. Meteorological Data System
COMNAVOCEANCOM	Commander Naval Oceanographic Command
CONUS	Continental United States
COPPERHEAD	Artillery Projectile
CPU	Centralized Production Unit
CWSU	Center Weather Service Unit
DACS	Data Acquisition and Control Subsystem
DCPLS	Data Collection and Platform Location System
DCS	Data Collection System
DMSP	Defense Meteorological Satellite Program
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DOT	Department of Transportation
DPSS	Data Processing and Services Subsystem
EBS	Emergency Broadcast System
EDF	Exploratory Development Facility
EDIS	Environmental Data and Information Service
E/O	Electro-Optical
EPA	Environmental Protection Agency
ERBSS	Earth Radiation Budget Satellite System
ERL	Environmental Research Laboratories
ESA	European Space Agency
ESM	Electronic Warfare Support Measures
ESSC	Environmental Studies Service Center
E/WEPS	Environmental/Weapons Effectiveness Prediction Center
FAA	Federal Aviation Administration
FACE	Florida Area Cumulus Experiment
FAMAS	Field Artillery Meteorological Acquisition System
FLENUMOCEAN	The Fleet Numerical Oceanography Center
FM-CW	Frequency Modulated - Continuous Wave
FNOC	Fleet Numerical Oceanography Center
FSS	Flight Service Station
FY	Fiscal Year
GAO	General Accounting Office
GARP	Global Atmospheric Research Program
GMT	Greenwich Mean Time

GMS	Japanese Synchronous Satellite
GOES	Geostationary Operational Environmental Satellite
GP	Genesis Potential
HEL	High Energy Laser
HIRS/2	Modified High Resolution Infrared Sounder
HRPT	High Resolution Picture Transmission
HRWS	Helicopter Remote Wind Sensor
ICAPS	Integrated Command Acoustic Prediction System
IDB	Integrated Data Base
IPADS	Interactive Processing and Display System
IR	Infrared
ITOS	Improved TIROS Operational Satellite
JDOP	Joint Doppler Operational Project
JSPO	Joint System Program Office
KM (or km)	Kilometer
M	Million
MAC	Military Airlift Command
MARK IV	Direct Read-out Terminal (U.S. Air Force and Army)
MAVERICK	U.S. Air Force Missile System
MGA	Meteorological and Geoastrophysical Abstracts
MMS	Meteorological Measuring System
MOS	Model Output Statistics
MSU	Microwave Sounding Unit
NAFEC	National Aviation Facilities Experiment Center (FAA)
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NAVEASTOCEANCEN	Naval Eastern Oceanography Center, Norfolk, VA
NAVOCEANCOMCEN	Naval Oceanography Command Centers
NAVOCEANCOMDETS	Naval Oceanography Command Detachments
NAVOCEANCOMFAC	Naval Oceanography Command Facilities
NAVOCEANO	Naval Oceanographic Office
NAVPOLAROCEANCEN	Naval Polar Oceanography Center, Suitland, MD
NAVWESTOCEANCEN	Naval Western Oceanography Center, Pearl Harbor, HI
NAWAS	National Warning System
NCC	National Climatic Center
NDBO	National Data Buoy Office
NDC	National Distribution Circuit
NEDS	Naval Environmental Display Station
NESS	National Environmental Satellite Service
NEXRAD	Next Generation Radar Equipment
NHC	National Hurricane Center
NHEML	National Hurricane and Experimental Meteorology Laboratory
NHELTR	National High Energy Laser Test Range

NMC	National Meteorological Center
NMMW	Near Millimeter Wave Program
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Survey
NOSS	National Oceanic Satellite System
NOTAM	Military Notice to Airmen
NSF	National Science Foundation
NSSFC	National Severe Storms Forecast Center
NSSL	National Severe Storms Laboratory
NVEOL	Night Vision and Electro-Optics Laboratory
NWR	NOAA Weather Radio
NWS	National Weather Service
OL-192	Meteorological Data Processing Group (Personnel)
OLS	Operational Linescan Systems
OMB	Office of Management and Budget
OPARS	Optimum Path Aircraft Routing System
P-3	Four Engine Transport
PATWAS	Pilot Automatic Weather Answering Service
PDP	Program Development Plan
PROFS	Prototype Regional Observing and Forecasting System
PTD	Preparation, Transmission and Display System
RCA	Radio Corporation of America
R&D	Research and Development
RD/T&E	Research & Development, Test/Evaluation
RFC	River Forecast Center
ROMS	Remote Ocean Surface Measuring System
RVR	Runway Visual Range
SAEL	Sensor Atmospheric Effects Library
SATCOM	Satellite Communications System
SBUV	Solar Backscatter Ultraviolet Instrument
SCM	System Control and Monitor
SDHS	Satellite Data Handling System
SEA	Science and Education Administration (Agriculture)
SEAS	Shipboard Data Acquisition System
SEASAT	NASA's Research Satellite Dedicated to Marine Observations
SEL	Space Environment Laboratory
SEM	Space Environment Monitor
SESAME	Severe Environmental Storms and Mesoscale Experiment
SFSS	Satellite Field Services Station
SM-1	Army Tank
SMS	Synchronous Meteorological Satellite
SOCC	Satellite Operations Control Center

SPC	U.S. Navy Satellite Data Processing Center
SST	Supersonic Transport
SSU	Stratospheric Sounding Unit
TACMET	Tactical Weather Equipment
TESS	Tactical Environmental Support System
TFU	Tactical Forecast Unit
TIROS	Television Infrared Observation Satellite
TMQ-22	Tactical Observing Kit (U.S. Air Force and Army)
TOVS	TIROS N Operational Vertical Sounder
TRADOC	Army Training and Doctrine Command
TWS	Tactical Weather Systems
UNIVAC	Computer System
USAF	United States Air Force
USAFETAC	USAF Environmental Technical Applications Center
USC	United States Code
USCG	United States Coast Guard
USDA	U.S. Department of Agriculture
USN	United States Navy
UV	Ultraviolet
VAP	Voluntary Assistance Program
VAS	VISSR Atmospheric Sounder (GOES D and subsequent space craft)
VHRR	Very High Resolution Radiometer
VISSR	Visible and Infrared Spin Scan Radiometer
VOR	Very High Frequency Omni Range
VRS	Voice Response System
VTPR	Vertical Temperature Profile Radiometer
WSCMO	Weather Service Contract Meteorological Office
WEFAX	Weather Facsimile
WETM	Weather Team
WFSC	Weather Facsimile Switching Center
WMO	World Meteorological Organization
WMSC	Weather Message Switching Center
WSMO	Weather Service Meteorological Office
WSCMO	Weather Service Contract Meteorological Office
WSFO	Weather Service Forecast Office
WSMR	White Sands Missile Range
WSO	Weather Service Office